

THE
NATURAL HISTORY
OF THE
MINERAL KINGDOM.
IN THREE PARTS.

PART I.

Of the Natural History of the Strata of Coal, and of the Concomitant Strata.

PART II.

Of the Natural History of Mineral Veins, and other Beds and Repositories of the precious and useful Metals.

PART III.

Of the Natural History of the Prevailing Strata, and of the principal and most interesting Phenomena upon and within the surface of our Globe.

By JOHN WILLIAMS, *Mineral Surveyor, F. S. S. A.*

IN TWO VOLUMES.

VOL. II.

EDINBURGH:
PRINTED FOR THE AUTHOR,
BY THOMAS RUDDIMAN.

1789.

3

NATURAL HISTORY
OF THE
MINERAL KINGDOM

IN THREE PARTS

JOHN HONKS

PART III.

IN TWO VOLUMES.

VOL. II.

PRINTED FOR THE AUTHOR
BY THOMAS C. LUTHER

1830

PART III.

Of the Natural History of the Prevailing Strata, and of the principal and most interest- ing Phænomena upon and within the surface of our Globe.

WHEN a gentleman takes a walk through his estate, or rides from home, he beholds various phænomena upon the face of the globe, which surpass his comprehension. In one place, he sees the rocks disposed in regular strata, but when he advances a little way forward, that beautiful regularity is broken, and nothing appears but disorder and confusion.

Now, it appears to me very unaccountable, and much to the disgrace of philosophy, that we should live so long upon the face of this globe, derive all our nourishment and all our conveniencies from it, and yet look upon the phænomena which it exhibits with an unintelligent gaze.

There is no room for this complaint in the other kingdoms of nature. A truly intelligent and successful spirit of enquiry and research has made great and wonderful progress in other branches of natural knowledge; but we are still in a state of infancy with regard to Mineral science.

Many fine things indeed have been said upon this subject by confident systematic theorists, and by studious, but inexperienced philosophers, which are disproved by observation and experience. It may be held as a maxim, that extensive and satisfactory knowledge of this subject is not to be gained at home.

Our powers are weak, limited, and imperfect, and the subject is vast, comprehensive, and various; and therefore we cannot, in the retreats of philosophic retirement, bring it near enough to examine facts. If we would wish to attain competent degrees of knowledge in the history of the mineral kingdom, we must survey its territories, we must follow the example of eminent proficients in other branches of natural history, who take a small portion of the subject of their enquiries

quiries at a time, and patiently examine all its parts piece-meal, by which method many useful and curious discoveries are made in the animal and vegetable kingdoms. I have in some measure followed this method in my history of the mineral kingdom; and as I have seen much, I shall state a considerable number of facts, drawn from my own observation and experience, for the entertainment and instruction of the intelligent naturalist.

In the prosecution of this design, I will observe the following method.

I. I will take a general view of the prevailing rocks and strata of this island, to see which of them are regularly stratified, and which of them are not, with the different degrees of stratification.

II. I will give the natural history of the stratification of our globe, of the bearing, slope, and continuity of the regular strata, and of the fissures, chasms, slips, and other interruptions of that regularity.

III. I will examine part of the modern system of Count Buffon, &c. upon this subject, to see how it corresponds with the real structure of the superficies of our globe.

IV.

IV. I will treat of the natural history of mountains---of their interior and exterior structure ; and I will examine and explain the external phenomena of mountains, and of their glens and excavations ; and I hope, that what I have to offer upon this subject will convey light and conviction to the intelligent and candid.

V. I will examine the nature, size, figure, and quality of the larger grains and fragments which are found in the composition of our rocks and strata.

VI. I will select some particular strata for examination.

VII. I will offer a few observations concerning several other interesting subjects relating to the mineral kingdom, among which is a treatise on Volcanoes.

In pursuing the method laid down, I am

I. To begin by taking a general view of the prevailing rocks and strata of this island, to see which of them are regularly stratified, and which of them are not, with the different degrees of stratification. And I will begin with the whinny and the argillaceous regularly stratified mountain

tain rock, for no other reason but because there is more of it found in Scotland than of any other kinds.

The regularly stratified mountain rock may be divided into several species or varieties, as,

1. Such as is found in regular strata of middling thickness, strong, hard and heavy, commonly of a black or blackish grey colour. This stone is generally mixt with grains and particles of quartz, shirl, and iron, though frequently in particles so small and so well mixed as not to be visible to the naked eye. This variety is common in many parts of Scotland, in high and low lands, and is called *whinstone*, but though regularly stratified, it is frequently too hard and strong to be commonly quarried for rubble-stones.

2. A sort thinner bedded than the former, and seldom quite so hard; nevertheless, this variety is much of the same quality and colour; it is always regularly stratified, and commonly makes excellent rubble-stone for building.

There is a curious variety of this stone found in the Highlands, and in several places in the north and south of Scotland, which may be called streaked or stripped, each stratum of the rock being composed of several strips of different colours,

lours, commonly white and black alternately, frequently white and grey, and sometimes different shades of a lighter and darker grey. Some of these streaks are not above the eighth part of an inch thick, and some are up to half an inch; but what is most remarkable of this stripping is, that the thinnest of these streaks spread out the whole breadth of the stratum of stone regularly, so that, when you see a clean section of one of these stones broke across the bed of the strata, these variegations have much the appearance of fine stripped cotton or other stuffs.

3. *Hastle-whin*, or the indurated hassle-coloured argillaceous strata, of which there are considerable varieties; some of which have a fine close uniform texture, thin bedded, and often containing distinct impressions of various small plants between the laminæ or folds of the strata, and some are of a more coarse and grilly texture; and the coarser sorts are generally found in thicker beds than the former.

4. Ash-coloured argillaceous mountain rock; some varieties of which are found more hard and strong than the hassle, and some more soft and tender.

This species or variety of the mountain rock is very common in many parts of the high and lowlands

lowlands of Scotland; and it is generally disposed in thin and very regular strata.

5. Argillaceous strata of a purple and a purplish brown colour, of which there is a great variety both in respect of quality and colour; some of it being indurated to a considerable degree; but much of the purplish argillaceous strata are soft and tender, and of a marly texture, apt to decompose or dissolve to clay when exposed to the air and weather. With this species or variety may be ranked all the brown and reddish brown argillaceous strata, of which there are great varieties; but as they differ little in quality and texture, and the diversity of colour is endless, I reckon, that it would be as useless as it would be difficult to enumerate them all; but they are generally all regularly stratified.

6. Blue, purple, ash-coloured, and grey strata, of a fine smooth grain, and of a slaty or laminated texture. The slate rocks are generally composed of fine particles, and these particles are as finely put together, the strata of them being extremely regular, and of a fine laminated structure, easily split or cloven with the grain, yet so strong, as with difficulty to be broken transversely to the bed of the stone. We may reckon, that the slate rocks are stratified in the highest degree of

perfection; and from the finely laminated texture of the strata, they cleave so thin and regular as to make a light durable and elegant covering for our houses. The fine blue slate of Eisdale and Ballachylish, in the Highlands of Scotland, are well known, and the blue slate of Stobo in Tweeddale is also well known; but there is a fine purple slate rock near Tombay, above Callender in Monteith, which is not so commonly known. This is a plentiful slate rock of excellent quality, and of a rich purple colour, which makes a most elegant and beautiful roof; but only a little of the loose and shattery surface of this rock has been worked.

They have not opened the quarry to any depth to get good and solid slate.

These slates may be carted to Stirling-Bridge, and then conveyed by water to any part of Britain.

7. Plate and schistus, of which there is a great variety, and a great quantity in many of our mountains and valleys. Some varieties of the schists or shivers are of the same colour and quality as the slates, the only distinguishable difference being in the stratification. The strata of slate are found as regular and as finely laminated as stone can be; but the plates and shivers on the contrary frequently exhibit nothing but a
confused

confused irregular mass; some of it as if it were half stratified, and a great deal of it without the least appearance of strata; and when there is an approach to regular stratification, it is to be observed, that the stone itself approaches to the quality of slate. I observed before, that there is more of the argillaceous than of any other particular species of rock appearing in this country; and, among the varieties of it, the schistus is the only one that is not very regularly stratified.

There is a great variety of the schistus, both in colour and texture, which is not stratified at all. Some of these are found in prodigious thick beds of a friable texture, appearing like an indigested mass, frequently containing balls and irregular masses of highly indurated stones of various sizes and colours. Some of the schistus are of a platy texture, separating into small thin scales and glazed masses of various sizes, all of them thin at the edges, with an oily or slippery smoothness to the sight and in handling. Again, some of the beds of schistus appear in a thick homogeneous formless mass, without any intermixture of balls or other hard masses, and some of it contains small masses of pyrites, quartz, &c. and I have seen much of the half or imperfectly stratified schistus in extensive rocks, containing considerable quantities of fine quartz in discontinuous veins or ribs, and in mishapen masses of various

ous sizes. This variety of the schistus is frequently pretty hard, and some strong beds of stone are often found in the beds of it; and where it is mixt or ribbed with quartz, it is not uncommon to find some masses of lead ore in it. I have frequently seen small quantities of lead ore in rocks of schistus in the Highlands of Scotland, &c. but I never saw it continue or come to any thing upon trial. I have seen great quantities of black schistus which had a very oily appearance, some of which will actually flame, but not consume in the fire. Part of the oily or inflammable schistus is of a scaly platy texture; and I have seen some of it very hard, and naturally separating into small irregular masses of various sizes and sharp angles. But it would be both tedious and useless to enumerate all the varieties of the schistus which I have seen as to colour, quality, and disposition of the beds.

Secondly, Granite rocks. The granite is a strong, hard, and heavy stone, of an irregular texture, composed of grains and fragments of various sizes, quality, and colour, of which there are several species which I have seen, such as,

1. Elegant reddish granite or porphyry of a gellied texture, in which the pale-rose, the blush, and the yellowish colours are finely mixt and shaded.

shaded. This is one of the finest and most elegant stones in the world. The mountains of Bineves in the Highlands of Scotland are chiefly composed of this stone, and it is found in great abundance in many other parts of Scotland; but I never saw this variety exhibit the least appearance of stratification.

2. Fine reddish granite, in which it may rather be said, that the same colours are blended together than spread out with such finely shaded tints as the former. I have not seen this variety of the granite stratified; on the contrary, both these exhibit such a degree of uniform regularity, that in some places there is no difference between a stone and a mountain, excepting only in magnitude, as many mountains of granite are nothing but one regularly uniform mass throughout, in which not the least mark of a bed is to be seen, nor hardly a crack or fissure, unless it be at the edge of some precipice or declivity. These two varieties of elegant red granite are frequently met with in the Highlands and Lowlands of Scotland, in Galloway, and many other places. We often find masses of talc so large in this second variety, that some of them may be called fragments, not disposed in any order, but higgledy-piggledy throughout the body of the stone.

3. Stra-

3. Stratified reddish granite, resembling the second in colour and quality, but not always quite so pure or free from admixture of other stony matter of a different quality. This variety of the granite frequently contains larger and smaller fragments of fine laminated talc. I have seen this granite disposed in pretty regular strata in the shires of Moray and Nairn, and other parts of Scotland.

4. White and whitish granite, generally of a loose granulated texture, containing a great quantity of mica, or small leaved talc, and the grains of quartz sometimes large and angular. This variety of granite is apt to weather and decompose, and part of it frequently dissolves, and the dissolution often falls to a sediment in lakes, so fine and light, as rather to hang suspended in the middle, and near the bottom of the water, than to sink in it. I have found this substance in many places, where water had been accidentally drained off, resembling fine shell-marl, only much lighter. When thoroughly dry, it is the lightest fossil substance I ever handled, and when blanched with rain, it is as white as snow. This variety of granite, either not stratified, or exhibiting thick irregular beds. It frequently contains a considerable quantity of talc, in masses and scales too large to be called mica.

The

The sediment which is found in lakes from the dissolution of the white granite, if perfectly free of ferruginous matter, is reckoned an excellent ingredient in the composition of fine china or porcelain ware. It is highly probable that this curious fossil is the kaolin of the Chinese.

The authors of the History of China inform us, that the fine porcelain ware of China is composed of two different fossil substances, called by them *petuntse* and *kaolin*. We are further told, that the *petuntse* is a fine white vitrescible stone, compact and ponderous, and of considerable brightness in the inside when broken, which they grind to a fine powder; and that the *kaolin* is not a stone, but a fine white earthy substance, not vitrifiable, at least not in the common heat of a potter's furnace: That they mix the *kaolin* and the flour of the *petuntse* together, and form a paste of this mixture, which they mould into all sorts of porcelain vessels.

Now, from the best accounts of this matter which I have been able to obtain, after a good deal of search and enquiry, it appears to me, that the sediment, which I have mentioned above, is the true *kaolin*; and that as the fine white glassy quartz, which is found in irregular masses, and in irregular discontinuous veins or ribs, in some of the rocks of schistus, is the true *petuntse*; and if this observation is really true, it deserves to be remarked,

remarked, that Scotland is as well furnished with the best materials for making fine porcelain as most countries in the world. The species of quartz, which I suppose to be petuntse, is of a pure fine uniform glassy texture, semi-transparent, and of a pure snowy whiteness. A broken piece of this stone, and a newly broken piece of fine porcelain, are very like one another. These hints are of such importance, that they deserve further enquiry, and a proper course of experiments to ascertain the fact, whether or not these fossils possess the real properties of the petuntse and kaolin.

If the island of Britain contains this valuable treasure, it ought not to lie buried for want of attention and industry. There is a great quantity of petuntse, or pure white quartz, in many parts of Scotland, particularly in the north and Highlands. There is a considerable quantity of it upon the shore, and washed by the tide, between Banff and Cullen, generally in pretty large masses in rocks of bluish schistus, and, to the best of my memory, it is very fine of the kind. There is also a considerable quantity of it in masses and discontinuous ribs, in rocks of blue schist, about three or four miles north of Callendar, in Monteith, upon the side of the high road, which runs parallel to Lochleodunich, which I also think very fine.

In

In some places this sort of quartz is tinged with a flesh colour from the neighbourhood of iron, which renders it unfit for porcelain; but there is plenty to be found of a pure white, in almost all parts of Scotland, without any mineral tinge whatever.

The kaolin is perhaps as plenty in Scotland as the petuntse, there being many extensive lakes easily drained, which contain a considerable depth of it; and moreover, it is to be found in many places that have been lakes, which are now laid dry by accident. There is a quantity of kaolin about a hundred yards below the public road, upon the south side of a bridge about a mile and a half or two miles south of the inn of Aviemore in the Highlands. It lies beneath a stratum of peat-bog, in a place which has been a lake, but is now drained by the river Spey cutting through one side of the mound which formed the lake. I think this sample very fine and pure, excepting that some parts of it may be a little discoloured by a light earthy sediment which lies above it. There is more than one stratum of the kaolin in this place, and some of it is exceeding white, especially when blanched by the rain; and there is a white granite rock up the rivulet, at some distance above the bridge, the decomposition and dissolution of which is supposed to produce this fine and curious sediment.

VOL. II.

C

Several

Several lakes in the Highlands of Scotland are nearly full of kaolin. I will at present only point out one of them, which is situated in the country of Stratherig in Inverness-shire, less than a mile north of the public road, and upon the west side of the farm of Drimin. It is a pretty long lake, the name of which I do not now remember. There is a considerable depth of kaolin in this lake, which may be drained at a moderate expence, and if I remember well, the granite rocks which surround it are pretty white and fine. It should be remarked, that if the kaolin originates from coloured granite, it is good for nothing, especially if it contains the least tinge of iron, because this will discolour and spoil the beauty of the porcelain; but wherever white granite is found composed of quartz, feldspath, and mica, without any admixture of shirl, and especially of iron, the kaolin should be diligently sought after in that neighbourhood.

I have been informed that Lochdoon in Galloway contains a great quantity of kaolin. This lake was drained some years ago, in the view to lay dry the shell-marl it was supposed to contain, which, however, upon trial, turned out to be kaolin. The one substance may very easily be mistaken for the other, as at first sight they are both very like the same; but they may be distinguished with certainty, by trying both with acids.

acids. Shell-marl will ferment strongly in weak vinegar, whereas, pure kaolin will not ferment at all in strong aquafortis. I have not seen Lochdoon, and therefore, I can say nothing about the granite of that neighbourhood.

5. Grey granite or moor-stone, so called in Cornwall, composed of black and white grains of various sizes. This stone is very common in many parts of this island, both in high and low lands, north and south. In some places it shews no marks of strata, and in others it is disposed into thick irregular unwieldy beds, which are commonly broken transversely into huge masses or blocks of various sizes and shapes.

There is a great variety of the grey granite, as well as of all other rocks. Some varieties of it differ but little in appearance or quality from some species of the basalts. Others are composed of almost equal quantities of black and white grains, about the size of small pease, whence it is called Peasy-whin by many Scotch masons. I have seen the grey granite, in Galloway and other places, exhibit a longitudinal grain or texture, as if the component parts had been all moved one way by a gentle flow of water.

When

When the grey granite begins to weather or decompose, which it often does at the outskirts of the rock, we can then examine its component parts, and we find some of it contain pretty large grains of a cubic, a rhomboidal, and other figures, and some of them so large as to deserve the appellation of fragments, and the largest fragments are always of quartz or feldspath, and of talc.

We meet with a great variety of colours, as well as quality and texture, of the grey granite. Some of it appears of a very light grey, and some of a very dark or blackish grey colour; and it is found of all the intermediate tinges or shades between these extremes.

6. Grey composite granite, the texture of which, when broken, looks as if composed of small fragments of various sizes and shapes, not unlike calveshead-gelly. When this stone is polished, the grains or fragments being all fine, they appear as if they were set or inlaid in a fine water-coloured pellucid matter. This is a most beautiful stone, but it is so long since I have seen any of it, that I do not now distinctly remember all its phænomena.

7. There is in some parts of Britain an imperfect granite of a loose friable texture, which is apt to weather, decompose, and be reduced to granite gravel.

gravel. There is a remarkable rock of this species near the Queen's-ferry in Scotland, on the road to Edinburgh, which appears in prodigious irregular thick strata.

This rock produces excellent materials for the high roads, and seems to be chiefly composed of quartz, shirl, and some iron.

8. There is a single stratum of very curious composite granite, a little to the west of Lofflymouth, in the county of Moray in Scotland, of about six or eight feet thick. This singular stratum is composed chiefly of grains and fragments of various bright and elegant colours, many, or most of which, are as large as pease and beans, and they are all fine, hard and semi-pellucid; and it is very remarkable, that there is about an eighth part of good lead ore in the composition of this stone, of the species commonly called potters-ore; and it is also remarkable, that there is no other granite in that neighbourhood but this single stratum; all the strata above and below it being mostly a coarse, imperfect, grey sand-stone.

9. There is also in many parts of the north, and Highlands, and in Galloway, an excellent species of grey granite, composed chiefly of red and black coloured grains. This is a fine, strong
and

and durable stone, very fit either for maffy or for ornamental architecture.

Thirdly, Limestone, which may be divided into the following species :

1. The grey, whitish, and pure white, regularly stratified, mountain limestones, of a granulated texture, broad bedded and strong, much used for building bridges in the north and Highlands of Scotland. Some of this stone breaks like coarse iron, but more of it like a sugar loaf, and I have seen much of it in the Highlands as white as the purest refined sugar, which may be called Parian marble ; and some of it composed of fine glittering spangles as large as the scales of fishes.

2. Coarse-looking grey mountain limestone, of a granulated texture, hard and strong, and difficult to work, exhibiting in some places a tumulous and unequal, in others a smooth and regular surface, and sometimes appearing on the sides of the mountains and lower moors, when the soil is washed away, like large sheets of dirty ice.

In some places this stone appears regularly stratified, in other places nothing appears but one vast irregular bed or rock, of very unequal thickness.

3. Ash-

3. Ash-coloured mountain limestone, composed of very small grains or particles of a fine smooth uniform texture, when broken, resembling flint. I have seen, in several parts of the Highlands, hills of this stone; some of which exhibit regular strata, and in other places, it appears in one great mass or sediment, like the granite rocks. In the island of Ila, and in the country of Assint in the Highlands, and several other places, this species of limestone exhibits an unequal jagged surface. These jaggs are sharp pointed, very hard and close to one another, and some of them a foot or a foot and a half long, which makes it both difficult and dangerous to walk upon this rock.

4. Regularly stratified limestone, found in the low countries, of which there is an endless variety of colours and textures not easily described, as grey, blue, black, brown, red; purple, and ash-coloured, with mixtures, tinges, and varieties of all these colours; and these are found of all degrees of hardness and purity, and resembling almost every other stone.

5. Limestones accompanying the coal metals, and frequently the immediate roof of coal. Of these there is a great variety, in quality, colour, and texture, and there is as great a variety in

in the degrees of purity, some of them being so debased with clay and other heterogeneous matter, that it is good for nothing, and others as rich and fine as any lime in the world. The limestones of the coal countries are always found in regular strata, and the strata of these stones are more regular in the line of bearing than any other species or division of them that have come under my notice.

I have seen many other limestones swell out in some places to a prodigious thickness, so as to cover a large extent of surface; and where rivers ran across them, the deepest glens did not cut through the limestone; notwithstanding, in advancing forward upon the line of stretch or bearing of the strata, I have seen a lime rock, which is in some places several hundred yards thick, dwindle away until it was cut by water, further forward, where it was not above two yards thick, and in some places it could not be seen at all; nevertheless, it would appear again and again still forward in the proper line. But this is not the case with the limestones of the coal countries. These are found as regular as the coals which they accompany, and the coal strata are more regular in continuation upon the bearing, as far as the class of strata belonging to the coal reaches, than any other that I have investigated;

gated ; and I look upon it, that this observation may be of use in practice.

The mason and the farmer may wish to find a known limestone at some distance from the place where it is seen. Let them keep the line of stretch or bearing of the strata, and in the coal country they will be sure to discover it at nearly the same parallel distance from a seam of coal or other given stratum, as at the place where it was last seen. But many of the mountain limestones are not so much to be depended upon. Though you may have a good and plentiful quarry in one place, yet, perhaps half a mile, or half a quarter of a mile further forward, you cannot discover it, and because it is not to be discovered ; it is dwindled away to nothing, and yet it will appear again farther forward ; which makes the mountain limestones uncertain to be discovered where you do not see them ; as these rocks very frequently grow thicker and thinner, and sometimes squeeze out to nothing ; and I comprehend under this denomination all the limestones not found accompanying the coals and coal metals.

I have observed above, that the limestones of the coal countries are always regularly stratified ; some of which strata are very thick, others very thin, and they are commonly found of all the intermediate thickneses.

The limestones of the coal fields are often distinguishable, by containing a great variety of shells, coral, and other marine bodies, which are found blended in the heart and composition of the stone.

6. Marbles of various colours, figures, and degrees of beauty and goodness. Some of these are found regularly stratified in layers of middling thickness, but they are oftener met with in thick irregular beds, which are generally broke transversely into blocks and pillars of various sizes, from one thick unwieldy stratum. Among these, the fine white statuary marble of Affint in Sutherland, is the purest and best I ever saw. I am persuaded there is none better, if any so good, in all Europe, and there is enough of it to serve all Britain, perfectly solid and pure, free of any blemishes, flaws, or stains, and blocks or slabs of any size may be cut out; but there is bad access to it, nor would it be easily quarried, there being a little cover above it, of a soft loose whitish limestone.

This marble accompanies a prodigious rock of grey limestone of a granulated texture, which appears in regular strata at Affint; but it is one of those which varies in thickness, as you advance along the bearing of the strata.

The

The good white marble of Affint is only to be seen in the bed of the river, near a considerable house, a mile or two south of the church ; but I cannot remember the name of the particular place.

It is a singular loss to the arts, especially to ornamental architecture, that men of fortune are not generally naturalists, at least, so far as to be acquainted with the peculiar distinguishable characters, qualities, and excellencies of the finer stones, and to be able to judge which is best for their particular purposes ; and not to be obliged, as they generally are, to leave it to the caprice or interest of the stone-cutter, to chuse for them, who is naturally supposed to study his present ease and advantage, more than the duration and future beauty of the piece.

When men of rank and fortune attend to the progress and encouragement of the arts, they are sure to arrive at considerable degrees of perfection in any country. Ancient Egypt, Babylon, Greece, and Italy, are so famous for their great works in ornamental architecture, for the rare qualities of their materials, and the excellent workmanship of some remains of antiquity, that they have been the wonder of many ages, and they still continue to be admired. It has many times vexed me to reflect, that our wealthy people

ple and eminent artists should send to foreign countries, for stones for ornamental architecture, when, perhaps, no country can produce so great a variety of the most excellent stones for that purpose as are to be found in Great Britain; and, therefore, in case posterity should grow wiser, I will point out a few of the places where I have seen singularly excellent stones, most of which are fit for any thing that ever was done in stone in any part of the world.

The first that I will take notice of are some excellent marbles.

1. A few miles from Blairgowrie in Perthshire, not far from the high road side, towards the north, there is an excellent, granulated, broad-bedded limestone, of a sugar loaf texture, and as white as the finest statuary marble; I look upon this to be a good species of the true Parian marble of the ancients; and as it may be easily raised in blocks and slabs perfectly free of blemishes, is uniformly of a pure white, and free and easy to be worked in statuary and other ornamental architecture, I think it only requires to be well known and brought into use, to become of great value.

2. There

2. There is some of this species of stone in the Duke of Gordon's lands, in the forest of Glenavon, composed of fine glittering broad grains like spangles, as large as the scales of fishes, but the situation is remote, and difficult of access.

3. The fine white statuary marble of Affint in Sutherland. The marble of Affint has a just title to an eminent rank among peculiar and excellent stones; and although I pointed out that marble in my general view of the limestones of Scotland, I will take the freedom to repeat here, that it is the whitest, the purest, and best that ever I saw: That there is none better, if so good, in all Europe: That blocks and slabs of any size may be cut out perfectly solid and pure, free from any flaws or blemishes whatsoever: That there is enough of it to serve all Britain, and much more; but there is bad access to it; nor would it be easily quarried, being situated in and under the bed of a small river, with some cover above it of a loose, soft, white limestone.

This excellent stone is of the purest white, and of a fine smooth uniform texture in the inside, of a bright appearance when broken, and of so fine and pure a quality, that the edges of a fragment are semi-transparent. In short, this is a very superior marble; but I am afraid, that the real best quarry is only known to myself. It is only

only to be seen in one place in the river, the rest of it covered with the white shattery limestone mentioned above. It is now twenty years since I visited that country, so that I have forgotten the particular name of the place. But a gentleman (I think Mr M'Kenzie of Ardloch) lived then in a large house near this marble, fine masses of which were to be seen in his office-houses. The marble is in the bed of the river, not far to the northward of that house.

4. Near the farm-houses upon the north side of the ferry of Ballachylish in Lochaber, there is a limestone or marble rock, of a beautiful ashen-grey colour, and of a fine regular uniform grain or texture, capable of being raised in blocks or slabs of any size, and capable of receiving a fine polish.

This singular rock is finely sprinkled throughout with grains and specks of fine bright mundick or pyrites, and likewise with grains and specks of beautiful lead ore of a fine texture, which to the eye appears to be rich in silver. This would make a bright and beautiful metallic marble.

5. In the farm of Blairmachyldach, about three miles south of Fortwilliam, in the bed of a river,

river, there is a very singular marble, consisting of a black ground, and flowered with white. This stone is of a fine close grain or uniform texture, but not very hard, and the flowering in it is light, elegant, and beautiful, like fine needlework, or rather resembling the frosty fret work upon glass windows in a winter morning; and this flowering is not only upon the outside, but quite through all parts of the body of the stone.

Secondly, Jasper, of which there is an extensive rock, near Portsoy in Banff-shire; some parts of that rock contain a beautiful mixture of green and red, &c. which appear finely shaded and clouded through the body of the stone when polished. I saw chimney-pieces of this stone in the old ruinous house of the Boyne in that neighbourhood, in which a considerable portion of red, or fine rose or blush-colour, is shaded with the green, and spread out in beautiful clouds through all parts of the stone. These jambs and lintels were exceeding beautiful, and retained the lustre of their polish undecayed. This would be a valuable jasper quarry, if properly opened; but as the body of the rock is hard and ill to work, I have seen no good samples of it, excepting the above-mentioned old jambs. Ill-chosen imperfect blocks are torn off from the outside of the rock, which hurts its reputation. I have seen
fine

fine rock there of great beauty, but I never saw any of it quarried, nor can it be quarried without skill and expence.

Thirdly, Agate. There is a large patch of fine agate upon the side of a hill near the church of Rothes in Moray, chiefly of a fine mixture of the red and white colours.

This is a very beautiful patch of rock. It is very hard and heavy, of a fine smooth uniform texture, and of considerable brightness, in which the red and white, &c. are remarkably clear, and finely mixt and shaded through the stone.

This is the largest and most beautiful agate rock I ever saw, and so fine and hard as to be capable of the highest lustre in polishing.

Fourthly, Porphyry, of which a great part of the hill of Bineves in Lochaber is composed. The porphyry of Bineves is a remarkably fine beautiful and elegant stone of a reddish cast, in which the pale-rose, the blush, and the yellowish white colours, are finely blended and shaded through the body of the stone, which is of a gelly-like texture, and is, undoubtedly, one of the finest and most elegant stones in the world.

About three-fourths of the way up this hill, upon the north-west side, there is found a porphyry of a greenish colour, with a tinge of a brownish red. This stone is smooth, compact,

compact, hard and heavy, of a close uniform texture, but of no brightness when broken. It is spotted with angular specks, of a white quartz substance.

Fifthly, Granite, which, with the granite-like porphyry above-mentioned, I reckon the glory of all stones, as all the beauties and excellencies of all other stones of mixed colours, are most eminently contained in these. The finer and most elegant red granite, and the finest granite-like porphyries, are so near a-kin to one another in quality and appearance, that I will not attempt a distinguishable description of them. Scotland is remarkable for a great number and variety of granites, of which I have given some account in my general view of the prevailing rocks of North Britain; and I believe, I may venture to say in favour of many Scots granites, that the world cannot produce any more excellent in quality and beauty.

The elegant reddish granite of Bineves, near Fortwilliam, is perhaps the best and most beautiful in the world; and there is enough of it to serve all the kingdoms of the world, though they were all as fond of granite as ancient Egypt.

There are extensive rocks of red granite, upon the sea-shore, to the west of the Ferry of Ballachylish, in Appin; and likewise at Strontian,

as well as many other parts of Argyle-shire. I have seen beautiful red granite by the road side, north of Dingwall, and in several other parts of the north of Scotland, which had been blown to pieces with gun-powder, and turned off the fields. There are extensive rocks of reddish granite about Peterhead and Slains; and both of red and grey granite in the neighbourhood of Aberdeen. The hill of Cruffel in Galloway, and several lower hills and extensive rocks in that neighbourhood, are of red and grey granite, where there are great varieties of that stone, and many of them excellent.

Upon the sea-shore, near Kinedore, west of Lossiemouth in Moray, there is a bed of stone about eight feet thick, which I think should be called a composite granite. This singular stratum is composed of large grains, or rather small pieces of various bright and beautiful stones of many different colours; and all the stony parts are exceeding hard, and fit to receive the highest polish; but what is most singular, about a sixth or eighth part of this remarkable stratum is good clean blue lead ore, of the species called potter's ore.

I know that the separate stony parts composing this stratum are all hard, fine, and solid, and capable of the most brilliant polish; but I do not now remember whether or not solid blocks
of

of it can be raised perfectly free from all cracks and flaws. If they can, I imagine, from the beauty and variety of the colours of the stony parts, and the great quantity of bright lead ore, which is blended through the body and composition of the stone, that this would be a very curious and beautiful stone when polished.

Sixthly, Basalts, of which there is a very great variety of the grey kinds in many parts of Scotland, and some of them are capable of the brightest polish. There is a good black stone of this species, formed into large columns, upon the south side of Arthur's Seat, near Edinburgh, of a fine uniform texture, and a good black colour, and capable of receiving a very high polish. This stone would be peculiarly fit for all sorts of ornaments about sepulchral monuments. It will polish to a bright and beautiful black, which will be unfading.

I shall now proceed to the seventh division of limestone, which is,

7. Stone-marle, or soft limestone, commonly found within regular strata, and of all the colours of other stones. I have seen of the stone-marles red, brown, purple, halse, grey, bluish, ash-coloured, and white, and some of them more variegated than any Castile soap.

The

The greatest quantity of the stone-marle dissolves upon the land in a few weeks, or at farthest, in the course of a season ; but there are found in some stone-marle pits particular strata, so hard as not to dissolve upon the land at all, without burning it into lime ; and yet, immediately above and below these hard beds, the marle is soft enough to dissolve in a short time.

8. Chalk, some of which is regularly stratified, and there is a great deal of it appears in thick irregular masses, like sediment ; but as it is now a long time since I was in the chalk countries, I do not pretend to be able to give a perfect account of this remarkable calcareous fossil. I have seen fine white indurated chalk brought from Ireland for burning into lime, in which the flints are promiscuously blended, as in the common chalks of England, the masses of which appeared to me to be broken off from regular strata when quarried.

Fourthly, The micaceous mountain rock, which is of a blackish and dark grey colour, hard and heavy, of a longitudinal texture, is exceedingly strong and difficult to break across the grain. This stone contains particles of quartz, shirl and pyrites, frequently of iron, and commonly holds so much mica in the composition of the stone, as gives

gives it a bright metallic appearance. There are extensive mountains of this stone in many parts of the Highlands, and in Galloway. It generally appears in pretty thick strata, which naturally break into flattish glebes of various sizes, but generally all very large.

Fifthly, Basalts, which abound in Scotland, of which a considerable quantity was carried from the Frith of Forth to London, for paving the streets. This remarkable stone is very strong, hard and heavy, of black or blackish grey, and all degrees or shades of the grey colours. Sometimes it is pretty fine in the inside, but more commonly of a coarse granulated texture, and some of it bright in the inside, when broken. The principal parts in the composition of this stone are grains of different sizes of quartz and shirl, as appears by the black and white glittering particles in it; and it commonly contains some iron.

This stone always appears in thick irregular unwieldy beds, and is found in many parts of Scotland, in high and low lands, in the isles and coal countries. Some of the beds of basalts are of enormous thickness; and where no other strata are found above, it is seldom of equal or regular thickness: On the contrary, where it is found uppermost, it often swells into little hills of various

rious sizes. Most of the small islands in the Frith of Forth, are rocks of this stone; and several hills in the neighbourhoods of Inverkeithing and Edinburgh, are formed of thick beds of basalt, such as Arthur's Seat, &c.

This singular rock may be divided into several species or distinguishable varieties, both with respect to the external figure it assumes, and to the internal grain or texture of the stone.

The most distinguishing characteristic of the basalt is this,—it assumes various figures, such as columns, glebes, balls, &c.

As to the *first* of these: The columnar basalts are frequently found formed into pillars of various sizes and lengths, having five, six, and seven sides; but columns of a quadrangular figure are not common. These columns are all smooth on the outside, and lie parallel and contiguous to one another, sometimes perpendicular, and often inclining in proportion to the position of the stratum which is thus divided: If the stratum lies horizontal, the columns are perpendicular; if inclining, the pillars also incline in exact proportion to the declivity of the strata, they being always broke right a-cross the stratum.

Some of these pillars of various lengths are only one entire piece from top to bottom; others are divided by one or more joints or pieces laid upon one another, which form a column of several

ral parts. The rock called the Giant's Causeway, in Ireland, as it is described, is a pretty good specimen of the jointed columnar basalts; but there is a more beautiful and more regular specimen of it lying above Hillhouse lime-quarry, about a mile south of Linlithgow, in Scotland; and a coarser one near the toll-bar north side the Queen's-ferry, and in several other parts of Fife.

The basalts in some places is formed into magnificent columns of great length; and in other places exhibiting an assemblage of small and beautiful pillars, resembling a range of ballustrades, or organ pipes. Some very long columns appear on the south side of Arthur's Seat, near Edinburgh; and there are several magnificent columns of great length, in the island of Egg, and many other places.

The columnar basalts, when broken, are frequently black, or of a blackish grey colour in the inside. Some of it is composed of small grains or particles, which gives it a tolerably smooth and uniform texture; and much of it holds larger grains in the composition, of a rough, sharp, and unequal surface in the fracture. But all the grains are fine, hard, and bright; and as the stone is compact, it is generally capable of receiving a very fine polish.

2. The second species or variety of the basalts I will take notice of, is not formed into columns, but into glebes of various sizes and figures, some of which are nearly quadrangular, or of a flattish square, with obtuse edges, and some of it assumes a round, an oval, an oblong, and several other figures; and these masses are found of all sizes, from the bigness of an egg to the size of a house. Although these stones differ from the columnar species in figure, they nevertheless have an exact resemblance in almost every other respect. The colour, quality, and internal structure is the same; and they are equally smooth on the outside, having all the edges rounded off; and they are equally strong and hard.

In short, the only distinguishable difference is the external figure, so that I think they can only be reckoned as varieties of the same species of rock.

It appears to me very evident, that this stone was broken and separated into this great variety of figure and size, by the chapping of the mass of matter, while the rocks were soft and humid, before induration was completed, by the stony matter shrinking into less room, as the moisture was draining off by evaporation, and otherwise.

The inequality of the sides of the columnar basalt, and of the size and figures of the glebeous, is to me a clear proof of their being first formed by

by the cracking of the stratum, while the humidity was exhausting.

It is a very common thing to see one stratum of the basaltine rock exhibiting in one place regular pillars or glebes, and near them very irregular ones, differing little from the common cutters which are found in all rocks ; and at no great distance, the same rock is found run together into one entire mass, exhibiting no tendency to be broke or divided into any distinguishable figure whatever. This observation is verified in the stratum of basalt, which is formed into pillars on the south side of Arthur's Seat, near Edinburgh, as well as in many other places I have seen, which makes it evident to me, that the formation of some part of such rocks can proceed from no other cause but the loss of humidity.

Some of these rocks only produce solid masses of different figures and sizes, and others produce different quantities of a softer friable stony matter, of the same quality in which the hard masses of different figures are found imbedded.

Pretty good specimens of the second sort of basalts are to be seen by the road side, between Cramond bridge and the Queen's-ferry, and in several other places in the Lothians and Fife.

3. Crustated basalts, which is not only formed into glebes and masses of various sizes, imbedded

in a less or greater quantity of the softer friable matter mentioned above; but these masses are also crusted round with several coats of the same basaltine matter, though these several crusts are in some degree more loose and friable than the solid masses of the basalts.

I have seen many quarries of this rock dug for the high roads, where the softer friable matter exceeded the hard masses in quantity, and in which encrusted stones of various sizes and shapes appeared. Some of the largest masses in such quarries have only a few coats of penetrable friable matter, surrounding a nucleus which varies in size, but which is uniformly hard throughout; and we shall find other yolks in the same quarry, imbedded in the softer matter, which, when broken, exhibit a nest of stones including one another like the several coats of an onion.

These crusted basalts which envelope one another are a curious species of stone. The several coats of surrounding matter differ nothing in quality from the stones contained in them, and some of the inner crusts are often very hard; but the nucleus within, though small, is always the hardest.

The decomposition by the weathering of the softer matter, found surrounding and enveloping the harder masses of stone in this and the second species of basaltine rocks, has produced a phenomenon

nomenon frequently met with in Great Britain, especially in Scotland, which greatly puzzles many. It is very common, in low grounds, and upon some moderate eminences, to see a prodigious multitude of stones of all shapes and sizes, very hard, and pretty smooth on the outside. These stones are sometimes so numerous and large, that it is often found impracticable to clear a field of them.

Where those stones are a species of the basalts, which they commonly are, and of the second class or species described above, in that case, they always originate from the decomposition of the more soft or friable parts of those rocks, which moulder and fall away, and leave the harder stones detached and scattered about, and the decomposed matter dissolves by degrees, and becomes good corn mold.

The singular appearance and enormous size of many of these stones, makes many people and even men of letters imagine that stones grow like vegetables. But it is very evident to our senses that stones cannot grow. They may, and many of them do, wear less and less, but they cannot grow larger, excepting in situations where there may be an accretion of particles of matter carried and deposited by water, by which process concretions and petrefactions are formed. These stony productions are formed and increased in
size

size by the continual accretion and addition of matter deposited by water upon the outside ; but this differs widely from vegetation. Others imagine that these stones were rolled about, the asperities and sharp angles were by that means worn off, and that they were all at last deposited as we see them by the waters of the universal deluge ; and their having obtuse sides and angles, as if they had been rounded by being rolled in water, makes these gentlemen confident that they are right ; and if we did not frequently find stones exactly of the same figure, size, and quality, in the rock, it would be very difficult to overthrow this hypothesis. I have taken great pains to investigate this point,—having frequently examined circumstances, and never failed to discover the stratum of rock which these detached stones originally belonged to.

The beds or strata of the several species of basalts spread as wide and stretch as far as the other concomitant strata in the neighbourhood where they are found ; but they often lie very flat, or with a very moderate degree of declivity, and consequently, when the softer and more friable matter, found in the interstices of these rocks, which incloses and binds the harder masses in their native beds, is decomposed, the harder stones then must lie scattered wide upon the face of the ground. Rocks of this species and description

description are so numerous in the Lothians, Fife, and other parts of North Britain, that it would be superfluous to point out examples to a Scots gentleman.

4. Crustated basalts, which is dry and friable throughout the whole mass. This species of the basalts is generally of a coarse granulated structure, and of all the various shades of the grey colours, from a rusty black to a light coloured grey. We see this species of crustated basalts developed when the masses are either broken or decomposing. There are masses of this stone of all imaginable sizes and shapes found in the rock, resembling in figure and size the second and third species of the basalts; and they appear alike smooth on the outside, with obtuse angles,—in short resembling the other basalts in every respect; but when they are exposed to the external air and weather for any considerable time, the several incrustations decay, decompose, and crumble down by degrees. When they quarry this species of basalts for the roads, they are able to break and pound them small with ease. Whereas, the harder species are so strong and cohesive, that they are with the greatest difficulty broken small enough for the roads.

5. Composite

5. Composite basalts, resembling the three last species in figure, colour, and all external appearances, as it is found in the rock, and in loose detached masses, but distinguishable from them only in the inner structure and grain of the stone.

This species of the basalts, which I call the composite, is not unlike some of the granites, as it is composed of much larger grains than the other species already described. Some of the larger grains in the composite basalts are a fourth, and many of them more than an eighth of an inch over, and they appear with smooth flat surfaces, and of a tabulated texture, exactly resembling the large quartz grains so commonly found in the composition of most of the granites. The chief or only distinguishable difference between the grains in each of them is in colour. They are evidently large grains of quartz, &c. which exhibit flat shining surfaces in both. These grains or fragments are commonly white, yellowish, red, or black in the composition of most of the granites; whereas, they are often seen of a pale blue, or a bluish grey colour, in the composite basalts, and some of them approaching to white. Nevertheless, after all I can say to point out the difference, this species of basalts has a very near resemblance to some of the granites in the component parts, and in the internal texture of the stone: but with respect to the external figure

figure of the masses, and the structure of the rock, or the manner in which we find all these masses formed and lodged in the stratum, it differs nothing from the other species of basalts.

6. The last species of this stone that I will take notice of is that which is indurated through the whole stratum, solid and uniform in all parts, and only exhibits such cracks and fissures or cutters as we discover in all hard beds of stone. We meet with many beds of this species frequently in the coal fields, and are often obliged to sink through them in our coal pits. The Salisbury Craigs near Edinburgh might be singled out as a good example of this species of stone, were it not that part of the same stratum is formed into columns upon the south side of Arthur's Seat; though I believe this is no good exception, as it evidently appears that the beds of basalts which are formed into columns, glebes, &c. only assume those figures where they are exposed to the influence of the external air, or have but little cover of rock above them. When any of those beds strike deep under the cover of several other strata, they are not found in columns, &c. Nothing but an uniform mass then appears, although the same bed is regularly formed near the surface, which proves, that the columnar and
other

other basalts are formed by shrinking and chapping.

I observed above, that the strata of basalts spread as wide and stretch as far in the longitudinal bearing, as the other different strata that accompany them in the countries where they are found. I also observed, that the rocks of basalts are generally found in very thick strata, and that in places where no other rock is found above the basalts, the strata of it are often very unequal in thickness. But this in general is only in situations where no other rock is found above it; for when it fairly enters into the superficies of the earth, so as to have other regular strata above it, which is seen in a hundred places in the Lothians, Fife, and other parts of Scotland, it then appears pretty equal in thickness; as equal as most other beds of such great thickness are; and yet it is remarkable, that although most of the strata of basalts are of great thickness, there are frequently thin strata of various kinds found both above and below it. We have numerous examples of this in all the parts of Scotland where the basalts is found, as for instance, there are thin and regular strata seen and quarried both above and below the thick bed of that rock in the Salisbury Craigs near Edinburgh.

In

In the Bathgate-hills, south of Linlithgow, and in many other parts of Scotland, there are several strata of basalts; and also several strata of coal, of limestone, freestone, and other concomitants of coal, blended promiscuously, stratum super stratum; and the basalts is frequently found immediately above, and immediately below regular strata of coal; of course, basalts is not the lava of volcanoes. We can prove to ocular demonstration, from the component parts, and from the situation, stretch and bearing of the strata of basalts, that they are real beds of stone, coeval with all the other strata which accompany them, and are blended with them in the construction of that part of the globe where they are found, as they dip and stretch as far every way as the other strata found above and below them. So that if basalts be a volcanic production, so must all other strata be of necessity: but how volcanoes should produce coal, and how that coal should be regularly spread immediately above and below strata of lava, is a little problematical; or rather, it is strangely absurd to imagine, that burning lava can come in contact with coal without destroying it.

Sixthly, The Breccia, or plum-pudding rock. This rock exhibits a very singular appearance in the superficies of the globe. It is composed of bowlders and water-rounded stones of all quali-

ties, and of all sizes, from small gravel, up to large bowlders, or rounded stones of several hundred pounds weight; the interstices being filled up with gravel and sand; and it frequently contains lime and iron.

When the breccia or pudding rock contains many large bullets of various colours and figures, it exhibits a formidable and grotesque appearance, discovering no marks of stratification, but appearing in one prodigious bed or mass of bullets of unequal thickness, frequently swelling to the height and size of a considerable mountain; and this curious rock is often so strongly cemented together, that the sides of the hills of it frequently overhang in frightful precipices, which are not so apt to break off as many other strong rocks in such situations; and the reason of this strong cohesion is, because this rock, when composed chiefly of large bullets, exhibits few cutters and fissures, but is frequently found in one solid mass of great extent and thickness.

But all the pudding rocks are not composed of such large bullets. Some of these rocks are made up of smaller parts, approaching nearer the size of coarse gravel. It appears evidently at first sight, that all the parts of the breccia, whether coarse or fine, have been rounded by agitation, and attrition in water, as the rocks differ nothing in appearance from the coarser and finer gravel,
found

found upon the beach of the sea, excepting only, that the parts are strongly cemented together in the rocks, and are loose upon the shores of the ocean.

I have seen some of the breccia composed of finely rounded stones of various beautiful colours, about the size of plumbs and nuts ; and all very hard and fine. If this stone was sawed and polished, it would appear as beautiful and elegant as any stone in Europe ; as it would much resemble Mosaick work in small patterns, and receive a brilliant lustre.

The breccia generally appears regularly stratified, or not, in proportion to the size of the component parts of the stone. Such rocks of this kind as are composed of round gravel and small bullets, are generally as regularly stratified as common sand-stone. Such again as hold bullets, like the first, and something larger, are commonly disposed into thick coarse beds ; and such rocks of it as are composed of the larger bullets seldom shew any marks of stratification at all.

There are numerous lesser hills and extensive tracts of this rock in many parts of the Highlands, and north of Scotland ; but as I shall have occasion to review this rock afterwards, as well as the basalts, and others, I will say no more about it here.

Seventhly,

Seventhly, The regularly stratified quartz mountain rock, of a white colour, a little tinged with a blue cast, and often of a bluish grey colour.

In many parts of Britain this stone is seldom found. I have seen some little of it in the north, and it is very common in the Highlands of Scotland, where I have frequently seen it as regularly stratified as any of the sand-stones, with other regular strata of different qualities immediately above and below it; and sometimes composing large and high mountains entirely of its own strata.

This stone is exceedingly hard, dry, and brittle, full of cracks and sharp angles; the different strata sometimes moderately solid, but often naturally broke into small irregular masses, with angles as sharp as broken glass, and of an uniformly fine granulated texture, resembling the finest sugar loaf.

There are large and high mountains of this stone in the shires of Ross and Inverness, which in a clear day appear at a distance as white as snow, without any sort of vegetation on them, except a little dry heath round the base of the hill.

Eighthly, I will take a short view of the coal metals, which are a very numerous class of strata; but

but as I have examined them particularly in my first volume, I will only take a cursory view of them here, and I will chiefly take notice of the sand-stones. There is a great variety of the sand-stones, which are distinguishable by colour, texture, and degrees of hardness; and these are disposed into thick, middling, and thin strata. The species or variety I will take notice of at present, is the regular broad-bedded free-stone, of a laminated texture.

This stone commonly rises in middling and thin strata; and appears at the edges of a section, when broke or cut, to be formed of different thin lamina, or layers of sand, equally laid on the whole breadth of the stone, and well cemented together.

I take no notice of the colour, nor of the several properties of the free-stones, having no view of classing stones. It is the formation into strata, and the internal structure of stones, with the various phenomena they exhibit in the stations they occupy in the superficies of the globe, that answers my present views. I have seen a great deal of both red and white free-stone rise in layers of five or six inches, and so upwards; and when the side of a grave-stone, or other slab, was polished, regular streaks, of a fifth or sixth part of an inch, appeared the whole length of the stone, as if laid on by so many gentle waves of water, spreading

spreading each layer. Now, I wish particular notice to be taken of the inner grain and structure of this stone, as well as of its regular stratification; and that the great regularity of the stratification, and the inner structure of it, correspond exactly; which I shall have further occasion to remark in what I shall advance in my second general head. The flaggy grey strata, the strata of slate in general, and many of the black and grey strata of the coal metals, may also be ranked with this free-stone, for perfect and regular stratification; and likewise many other thin strata of the coal metals.

I will also bring many of the thin argillaceous strata into the same view. Many of the grey regularly stratified mountain limestones are also streaked or striped; and the streaks in these appear more conspicuous, when broken, than the streaked free-stones; the colours of the parallel streaks or strips being brighter. I observed before, that some of the hard regularly stratified mountain rocks are streaked; and in all these three different stones, it is to be remarked, that the streaks are all regularly and exactly parallel to the bed of the stone; which sufficiently proves, that the same agent was employed in the formation of these, and of all the completely stratified metals; and that this agent acted with much regularity.

Ninthly,

Ninthly, The grey flaggy strata of Caithness, is another remarkable instance of regularity. The rocks of all the low country of Caithness, a square of ten or fifteen miles, are bluish grey argillaceous strata, with generally a small quantity of lime in the composition of the stone, which is indurated to a greater degree than is common to such thin strata.

This stone is strong and tough ; and all over this country it is disposed in thin, broad-bedded, regular strata. In several parts of the country, these flags are so thin and regular, and are raised so light and broad, that three or four of them cover the side of a small house. Mr Murray of Castlehill has, perhaps, the best flags in all Europe, in a bay upon the south side of the Pentland Frith. That gentleman raises them of any size and thickness he pleases ; and so truly flat and smooth, that he has only to square the edges to make of them good loft floors, partitions, chests, mangers, roofs of houses ; in short, he does every thing with them.

The face of these flags are as smooth and true a plane, as if a perfect master had finished them ; and indeed, they were finished by a perfect master. The adorable Creator is the author of all this art and regularity : And the strata in this bay is a beautiful instance of perfection in the works

works of nature, with respect to regular and perfect stratification.

There are several other rocks and species of stone in Great Britain besides those already enumerated and described, many of which I have seen and examined; but these comprehend a sufficient number and variety to answer my purpose in the sequel of these inquiries. I have no view nor any inclination more minutely to arrange and classify stones. I am acquainted with gentlemen much more capable for such an undertaking. My plan and genius leads me to examine the strata which compose the superficies of our globe upon a large scale. I delight to examine the rocky shores of the ocean,—to climb the lofty mountains, and take an extensive view of the great operations of nature, and then to retire into the deep and solitary glens, where I see the anatomy of my subject,—where such deep, various, and extensive sections of the strata are found, as are very useful and very necessary in this investigation.

I will now proceed to my second proposition, which was,

II. To give the natural history of the stratification of the superficies of our globe,—of the bearing, slope, and continuity of the regular strata,—
of

of the fissures, chafms, slips, and other interruptions of that regularity ; all of which concur in proving to a demonstration, that water was the principal agent in the formation of that superficies.

I have thus far prepared matters for entering upon an enquiry into the formation of the strata ; an enquiry arduous and difficult ; and although it has occupied much of my attention more than forty years ; and although, some time ago, I have endeavoured to remove many difficulties which obstructed my progress, yet when I approach to a more minute investigation, it fills my mind with awe and reverence. The origin, the history, and the delineation of this chaos, form so great an undertaking, that I dare hardly venture to explore those dark and mysterious regions of nature.

All the phænomena of the strata, and the partial history I have given of them, make it evident to me, that those rocks and fossils which we see laminated, streaked, and spread out one above another, were formed by the waves of water put in motion by the tides and other natural causes : And that other rocks, such as most of the granites and pudding stones, some of the basalts and limestones, &c. have striking appearances of the stony matter subsiding in deep water, and subsidence cannot properly take place in water greatly agitated or flowing with a strong current.

It now begins to be acknowledged by almost all those naturalists who enquire into the nature of the mineral kingdom, that they see the marks of water every where upon the superficies of this globe. M. Buffon asserts, that every thing we see both upon and within the surface of the earth, carry self-evident marks of the whole being formed by water, and he is evidently right in general in asserting, that water was the agent in this great work, but he is as certainly wrong in his account of the manner of performing it.

From all the phenomena which we can investigate, both upon and within the superficies of the globe, it appears, that all the materials which compose our rocks and strata, must have been mixed with water in a fluid or chaotic state, when the superficies of the globe was formed, and all its curious rocks and strata were organized.

At present I will take it for granted : I shall have occasion to resume the subject hereafter, and to make various enquiries relating to this chaotic state of our globe.

It is natural to suppose, that the diurnal motion of the earth from east to west upon its own axis, and the motion of the tides from east to west, were not suspended while this planet was in a chaotic state before the present dry land appeared. Upon this supposition, it seems to me highly probable, that those strata which we see dis-
posed

posed into regular order, were formed by the flow and waves of the tide spreading out the grains and particles of stony matter upon a large plane, and leaving them there. The phænomena of the strata themselves, and a slimy sediment found betwixt the beds of many quarries, make this hypothesis abundantly evident.

The most of the granites and breccia, some of the basalts, limestones, and others not regularly stratified, I suppose were formed by the stony matter subsiding when the water was in some degree of rest at the height of the tide, or from other causes of stagnation. Great quantities of matter lodged by a particular high tide in different places, might make many large temporary obstructions by water containing great quantities of stony matter, which would subside into a thick irregular stratum during the recess of the tide; which obstructions future high tides would break down and sweep away.

I am convinced, by the phænomena of the strata, that every stratum which we see regular was formed upon the then surface of the globe; that is, that the very part of the globe where a particular part of the stratum was made, began to be dry land before the tide brought with it the matter which produced that stratum; and so on, stratum super stratum, tide after tide, until all the strata were completed. And perhaps higher
and

and lower, stronger and weaker tides, might have been the cause of thicker and thinner strata, amongst those we call regular. We find the thick and thin strata very unaccountably and capriciously mingled, unless we will allow such a natural cause as the difference of tides.

I am also convinced, that when every individual stratum was made by the tide, that stratum was spread out by the water upon nearly an even level plane superficies, extending the whole length and breadth of that stratum; and that the inequalities of declivity, the fractures and various irregularities we meet with, happened after each stratum, and in many cases, after a great number of strata were spread one above another upon a level surface.

To compare great things with small, the strata of sand and mud lodged by great rivers in plains, by inundations from the mountains, are disposed in layers very much resembling our strata of stone, &c. I have read an account of a deep well or pit dug in Holland, in which they found thicker and thinner strata of clay, mud, and sand alternately, to the depth, if I remember rightly, of about thirty or forty feet. There is no room to entertain a doubt, that these strata of loose matter were spread out there at different periods of time, by the inundations of the Rhine, &c. and those several strata dug through in Holland being

ing found in a loose state, without any appearance of cement or induration, is a proof of an observation I made in another place : viz. That such adventitious strata as are formed by accident upon the shores of the ocean, the banks of rivers, &c. at any time since the first formation of the superficies of our earth, want the cementing quality which binds and connects our rocks with various degrees of cohesion.

These adventitious strata assist our ideas in forming a proper notion how the great work of the stratification of the superficies of our globe was performed ; and providentially these accidental strata are all perfectly loose and unconnected, without the least approach towards any thing like cementing, induration, or cohesion.

I hope it will be acknowledged that this account of the formation of the strata and rocks upon the superficies of our globe, appears natural : At the same time, I am sensible it may be alledged, that it points at regularity, but regularity is no where found in continuation. I own, it may appear so at first sight. However, I hope to convince every unprejudiced enquirer into these matters, that all the various declinations, breaches, and other interruptions to regularity we meet with in the strata, are all, upon this hypothesis, natural and necessary.

Let

Let us suppose that the interior parts of the earth, below the visible strata, were formed by subsidence, and that from the agitation of the tides, this interior rock, as we may call it, would be full of greater and lesser inequalities upon its superficies, before the exterior rocks and strata were formed. The great agitations of the waters or chaos, and the great run of those high tides from east to west, would undoubtedly carry and lodge the stony matter in great inequalities. Admitting the chaotic state of the terraqueous globe, it is impossible to conceive that it could be otherwise; and the phenomena of the granite and pudding rocks greatly countenance and illustrate the position. Several mountains in Lochaber and in Appin, the mountains of Carngorm, amongst many others in the Highlands of Scotland, and Cruffel in Galloway, shew us how the granite rocks are most commonly formed; and the pudding rocks upon both sides of Lochness, in Ross-shire, Sutherland, and many other places, I have seen exhibit much the same phenomena.

In the cursory view I took of the prevailing rocks of Scotland, it appeared, that there is, comparatively speaking, but a very small part of the granite rocks found in regular strata. Sometimes we meet with this rock lying moderately flat and level, often disposed into low inequalities; but the most common appearance of this rock is in
hills

hills and mountains, some of which are of great size and height ; such, for instance, are the mountains of Lochaber, Appin, and Carngorm, in the Highlands, and of Cruffel in Galloway. The most of these mountains, and many others of the same quality, which I have seen, are composed of one entire stone or mass, from top to bottom, without the least appearance of strata, or any divisions into different layers, or beds ; and often with very few of the common fissures or cracks, which are so frequently found in other rocks.

I went up the bed of a large rivulet of four miles, in nearly a straight line, upon the east side of Bineves, in the Highlands, where the granite rock was washed clean the whole length of the rivulet, in which there was no appearance of any division or bed, nor hardly a crack or cleft a quarter of an inch wide to be seen ; but the whole rock was uniform and equal like the superficies of a single block of granite. Now it is impossible for us to meet with any thing in nature, that can give us a clearer idea of the stony matter subsiding in water with unequal superficies, than these mountains of granite, and the lesser hills of the breccia, or pudding rock, exhibit. That these mountains of granite, and other unstratified rocks, have subsided with unequal superficies, is evident to every observer ; and in such cases, there is no disputing against self-evident

evident facts, without being guilty of the greatest absurdity.

Various phenomena of the earth make it very evident, that the tides rose to a prodigious height during the formation of the rocks and strata, which compose the superficies of the globe. The fluid chaotic state of the terraqueous globe, was one reason of such high tides at that period. The attraction of the sun and moon would have a greater effect upon this planet, when the superficies of it, at least, were all in a fluid state, than they could possibly have afterwards, when part of it only was fluid, and part solid. And the tides rising so high in that state of the earth, was the cause of our meeting with so many mountains of granite; some of which, though high, must have subsided altogether in one tide, which is evident, from their containing the same matter without any variation in quality or colour; and from their being one uniform mass, without strata, division, or bed, from top to bottom, that can give us the least indication of the matter being laid on, added, or subsiding at different times. But this is only to be understood as meaning such parts of the mountains as are in our sight. We can say little or nothing to such parts as are not in our view.

As it is evidently matter of fact, that the mountains of granite are of the construction
which

which I have described, it must be acknowledged that the tides were high when those mountains were formed. In this case the effect proves the cause, and the cause naturally accounts for the effect. Now, from these known facts which we can investigate, we may form probable conjectures in cases perfectly similar. When we see inequalities upon the superficies of the granite, and other rocks formed by subsidence, so considerable as to rise to the height of great mountains, it is rational to conclude, that similar inequalities would be occasioned by the subsidence out of our sight. During the first periods of the subsiding of stony matter in the waters, I think it a reasonable supposition, that the interior parts of the globe would consolidate before the superficies. Besides the pressure of the superincumbent chaotic matter, the attraction of the sun and moon would be more powerful near the surface than further down, which would help to keep the more superficial parts of the chaotic or earthly matter more loose and mixed with water; and of course, the sediment near the surface of the globe would be last in forming, and would be very humid and cavernous, as well as unequal and of a mountainous figure.

Having thus far prepared my way, I will now proceed to account for the inequalities and breaks of the strata. When the then superficies

of the consolidated parts of the globe began to rise so high, or nearly so high, as the surface of the globe, so as the tides would begin to run and to form strata, the first as well as the last of those strata would be spread out even and smooth upon a large superficies. Now the first of these strata would be spread out upon a very unequal and insufficient ground, which was not only of a mountainous figure, but also containing a great quantity of water in the composition of the sediment; and some of the caverns and hollows would be much more humid and slimy than others; and therefore, when the weight of the super-incumbent strata were laid by succeeding tides above this unequal, terraqueous basis, and when the superior waters began to lessen in bulk and weight, by the separation of the earthy and stony matter, and to retreat by degrees to the present bed of the ocean, and much dry land began to appear between tides, before the induration of the strata had taken place, it became necessary that the water contained in the caverns and hollows, and in all the humid sediment below the strata, should find its way out. The weight of the superior strata, as yet humid, soft, and flexible, would press hard upon the unequal ground below; and this pressure of the super-incumbent weight, would in time become so great, that the water below must force its way out, by
breaking

breaking the superior strata in many places ; and this forcing up of the interior water, drained out of the humid sediment, is the origin and efficient cause of all the caverns, gashes, veins, and fissures we so often meet with, and behold with astonishment. A great quantity of water forcing its way out would make a large passage ; and the violent manner by which this passage was made, would greatly disturb and distort the strata about the rupture. When the water had forced its way out with a violent eruption, the strata being still tender and humid, the aperture or cavern would, in whole or in part, be filled up by the falling in of the sides or roof, which would disturb regularity, and produce confusion and disorder a good way round. While the superior strata were borne up by the waters beneath, and continued whole and unbroken, they were all horizontal and level, or nearly so ; but when the interior waters forced their way out, by bursting the strata in many places, there would be made considerably unequal vacuities underneath the strata ; and of course, the strata being not yet indurated, there would soon be great alterations upon the superficies of the globe.

The yet humid and tender strata would bend and break in many places, and sink down into the vacuities beneath, which has caused the various declivities, ruptures, and other interruptions of
the

the regularity of the strata, which we every where behold. Where the interior vacuity was very deep, the parts of the strata immediately above such vacuity would be depressed so low, that the other parts which would rest upon the side of an interior mountain, would be turned up nearly an edge. The strata would dip and lean into these interior lakes, gulphs, and vacuities, with all the varieties and degrees of slope, of elevation, and depression, which we every where meet with.

I saw at Springkell in Annandale, a deep limestone quarry, which exhibits the under or concave section of an arch. I had an end or profile view of this section, which was the best. The upmost stratum of this rock, next the grafs, was very short, as that small segment of the arch soon cropt out to the north, and to the south. The second stratum down from the grafs was considerably larger than the first. The third and fourth, and so on, continued to lengthen all the way down to the bottom of the quarry, as both ends or sides of each stratum below came round and cropped out at the grafs above, as high as the upper stratum cropt out; so that all the lower strata took an ample sweep, and formed the concave semicircle of a magnificent arch.

This is a curious and a pleasing phenomenon, which I know not how to account for, without admitting

admitting a vacuum underneath these strata, into which the middle of them was depressed, and the sides elevated while they were humid and pliant. It was this inequality of the ground below the strata which was the cause of all the dykes, gashes, slips, and other inequalities and disturbances in the coal metals. A vacuity of a certain extent and deepness would occasion the strata above to fall into just such a degree of slope as the size and figure of the hollow below would admit of. Where the vacuum was deep, and the sides of the subterranean mountains very steep, the strata above would fall nearly on edge; and when shallow, they would only be depressed a little, which would give them an easy slope or declivity, and so on to all the intermediate degrees between the two extremes of the horizontal flatness and the vertical position of the strata. Where the inequalities below were inconsiderable and near to one another, the superior strata would only bend downwards a little in several places contiguous without breaking, which would occasion the inequalities of dip and the waving of the strata, which we so often meet with, and which I have described in my observations on coal.

When a small vacuity happened to be greater under one side than the other of a class of strata, the weight of the strata over such vacuity pressing
down

down on one side, and the resistance of the other side, which was supported below, would at last cause them to break across, and the strata upon one side of the breach would sink down, and the edges of the several strata would slide past each other at the fracture, so that the edges of those which sunk down would fall below the edges of those they broke off from, on the side which stood firm, as many feet, or as many fathoms, as the vacuity below was deep or shallow, which was the cause of all the slips and hitches we so frequently meet with in coal-works and quarries, and we see in other places where the strata appear.

I apprehend we may find another source of water to disturb the regularity of the strata, besides that I have attempted to explain. The superior strata and rocks formed by the water and in the water, as the matter was laid on by the streams, or lodged in sediment at the height of the tides, would all at first be in a soft and humid state, containing a considerable quantity of water, which would all by degrees ooze and drain out by the pressure of the superior upon the inferior strata; and it is the property of water to sink downwards, excepting such as goes off by evaporation, when the particles are divided so small as to be buoyant in the air. The water contained at first in the composition of the superior

rior

rior strata, while humid, when passing downwards by percollation, might for a while lodge betwixt some strata, or in any vacuities it would find; but when the superior pressure became greater, by the addition and settling of the strata, this water would also force its way out; and this, very probably, is the physical cause of many of the lesser disturbances and deviations from regularity, which we so often meet with in the coal metals and others. It is more than probable, that the water strained out of the strata might in some places produce even considerable disturbances in forcing its way out.

It appears to me probable, that the water drained out of the strata, and afterwards forced out from between them, might occasion that sort of disturbance in the coal metals and others, which I have called a waving shake; and perhaps some of the lesser twisted shakes, which I have described elsewhere, might have the same original cause. The water between the strata bursting a passage in a particular place, and in forcing its way out, breaking, twisting, and distorting them, would produce great confusion as far round as the influence of that current would reach. And I can easily conceive, that in many places, this water would be forced out with prodigious violence, by the great weight of the strata above pressing down upon it. In the formation

tion of the strata by water in motion, it is reasonable to suppose, that some places would contain more water in the mud or newly formed strata than others, and of course such places would be more quaggy and weak than firmer places, which contained less water; a pressure coming against such a place would easily force a passage, and if such weak place was of small extent, the water might force its way upwards in almost a vertical direction, and so form a twisted shale or a single pipe vein in mineralogy.

We often meet with quaggy spots upon a smooth sandy or limy shore, so soft and wet, that you will plump in if not previously aware of them; and sometimes the water will really burst out of these quaggy places, although the rest of the sands near you shall be comparatively dry and firm.

I make no doubt, that one or other of these causes, which in many respects are the same, have produced all the phenomena we observe within the surface of the earth, wherever we meet with any thing that disturbs or interrupts the uniform regularity of the strata.

It is a common saying with many, (which I have often heard), when they meet with phenomena in the mineral kingdom, which they cannot comprehend, to call them "the sport of nature," which is at best but a vague expression, frequently

frequently made use of to conceal ignorance. I think it a much wiser saying made use of by others, viz. "That nature does nothing in vain." I cannot help thinking that the last saying is remarkably applicable to the subject under contemplation. Granting the strata to be formed by water, and I do not see how it can possibly be denied by any who take the trouble to examine circumstances; we must then suppose a great quantity of water to be contained in the composition of each stratum at first, and that this water would filter and strain out by degrees. It is as reasonable to suppose, or in other words, it is necessary to allow this water a passage out somewhere. Go to a sandy or slimy shore, towards the latter end of the ebb of a high stream tide, when the sea retreats expeditiously, and there you will see how amazingly fast the water is oozing out of the stratum of sand which the waves formed, and the greater the slope is near the land, the quicker it drains out.

If the shore is very flat and the sands extensive, it contains so much water that we dare not ride there. I have frequently seen sands I durst not walk upon, and men on foot and on horseback have been known to sink and perish in them. The Solway Frith is infamous in this respect. Several barques striking the ground, could never be got off the sands again, but have

been known to sink over the mast quite out of sight in a few tides. This observation will help us to conceive what an amazing quantity of water there must have been in the composition of the strata when first formed; and if we find it there, we must allow it a passage out somewhere: It would force its way out when a prodigious weight of strata was laid on above, and the waters of the ocean had retreated far below the level of the dry land.

In a subject so great and extraordinary as this, we must either compare great things with small, or else be left without any means of illustration, without any thing to assist our ideas; and we have need of all the assistance we can possibly find to aid us in this investigation. Allow, then, that the newly formed strata and unstratified rocks did contain much water at first, this water must find or force a passage out; and I have no reason to doubt, that the breaking out of the waters from beneath, and from between the strata, in greater or lesser quantities, from all depths, and in all directions and degrees of force, was the physical, the necessary cause of all the great fissures, breaks, caverns, abruptions, twists, shakes, and other confusion and irregularities we meet with in the strata. I have seen examples which assisted to confirm my persuasion, that the greater the incumbent weight above where water broke

broke out from a great depth, the greater and wider confusion it made.

I have seen great havock made in the strata, in some places upon the shores of the ocean, under the sides of large granite mountains. But I will not descend to particulars. It would prove too tedious ; and every observing naturalist who will take the trouble, as I have done, of perambulating the mountains, valleys, and shores of the ocean, will find the truth of all my observations. Every curious person will find opportunities to examine particulars. I only wish in general, to be able to set the observations and reflections of the inquisitive in a right train.

I have excepted the gashes, or the open fissures, which are wide above, and narrow below, from the interruptions of the regularity of the strata and rocks, which were occasioned by eruption of the inferior waters. At the same time, I am perfectly clear that the water contained in the sediment at first was the mediate cause of these gashes. The drying of the superficies of the strata, by evaporation and percolation, was the immediate cause of them. When the great quantity of water contained in the mass at first, drained, evaporated, or issued out, the superior strata must shrink every way in bulk ; and besides their diminishing in bulk from the loss of so much water, the strata, as I observed before,
would

would fall, lean, and slide every way upon the water making its way from beneath them; and these effects jointly were the cause of the gashes, or wide chaps of the rocks and strata: Or in other words, when the superior strata began to consolidate, and the water was drained out, they would crack, and the inclination of the strata, different ways, would increase the crack to a wide gash.

I think this part of my subject as clear, or as easy to be illustrated, even by small examples, as any part of it I have treated. We see the earth chap in a dry summer. A brick-maker's clay spread out, and left too long in the sun, without working, will soon crack all over. I have observed in divers places, that the superior or upper strata were chapped more than others below them. I mean, that a small part of rock or strata spread over a limited extent of country of a particular quality, above which there is no appearance of there ever having been any other strata, and not much cover of any kind, exhibit the greatest number of chaps. Such, for instance, is the limestone of the island of Isla, and of Assint, which does not dip under the mountain rocks of the country. The limestone of Isla is stratified, but there are no other strata of a different kind above it. I have traversed the whole of that piece of limestone, which is about ten miles over,

over, and I never saw any so full of chaps and fissures as it is. This remarkable patch of limestone is altogether a mining field, which produces various species of lead ore, and some of them rich in silver. But the prevailing species in the island, is the common blue potter's ore, which is there remarkably clean when dressed, and free from pyrites and other heterogeneous mixtures, not easily separated; and it yields an excellent produce in smelting. Some little copper is found in this field, in regular mineral veins, but lead generally prevails. I believe no country produces such an amazing number of veins, in the same extent of ground, as appears in this limestone. The number surpasses imagination, and many of them are as promising regular good veins, as can be seen in any mining field; and they all discover less or more lead, accompanied with the best mineral soils, hard and soft. But notwithstanding the surprising number of veins to be seen in this rock, I believe it would be difficult to determine which are most numerous, the mineral veins, or the hard whin dykes, which cut and intersect the lime in all possible directions. If the veins and dykes of this field were distinctly and properly delineated upon a large scale, by a good surveyor, it would be a valuable acquisition for the curious and intelligent.

The

The whin-dykes there generally rise above the surface of the lime, so as to be seen in ridges at a distance, intersecting one another. I have frequently stood upon an eminence, and viewed with astonishment the prodigious numbers of these ridges of stone which traverse the lime-field, crossing and intersecting one another in all directions. I account for the whin-stone, and other dykes in limestone, and the coal metals, &c. as originating from the same physical causes as the open gashes, viz. the draining of the humidity, and drying of the strata.

The whin-dyke was a gash or chasm at first, which was afterwards filled up by a high tide overflowing and pouring foreign matter into the gash; and the gash which continues open, or only contains sand or clay, or other loose matter, I suppose became gashes later, by the cracking of the surface of the rocks, after the high tides were so far retreated into their ordinary bed, that they would no more return to cover the earth.

We should not look upon all this irregularity, all these caverns, fissures, breaks, and other interruptions of regularity, which I have been describing, as if they were real blemishes in nature, of no farther use than to answer the first purpose of giving vent to the superfluous moisture out of, and from under the superior strata. I consider them

them all, or most of them, of great emolument to man.

The fractures in the superior strata, and the depression and elevation of them into various degrees of slope, gives us an opportunity of viewing their edges at the many sections of them we so often meet with, and of examining their crops or upper edges of the several strata, which enables us to chuse what is useful, and to discover and work coals, quarries, &c. The great subterraneous caverns and passages often give vent to noxious mineral vapours, and are frequently the channels of subterraneous rivers, many of which run into the ocean, and into great lakes.

Many of the gashes and larger fissures in the strata, are the repositories where the mineral ores are treasured up for our future use, and we know where to find it and draw it out, as the advanced state of society, of commerce, and the arts require it. What a blessing to Society in general are the metals! What a comfort to many cold countries is pit coal! how necessary to the arts, manufactures, and commerce! How could London, Edinburgh, Dublin, &c. subsist without it? Their conveniences and advantages, without these, would be greatly diminished: It must be confessed, they could not be what they are without it.

Those

Those smaller cracks and fissures we every where meet with in great numbers, in the strata commonly called cutters by our quarriers, which cutters divide our quarry stones into so many blocks or masses of various sizes and figures, are considered by many as the effects of earthquakes and other violent concussions; but it is very evident to me, that they originate from another cause. Every person of observation and experience knows very well, that the nearer the surface, the cutters appear more numerous; and *vice versa*, the deeper down there is the greater distance between them. I have seen many good quarries in which the strata were divided at the surface by these cutters into angular masses too small for use, which produced good blocks a little way down, and at a greater depth, there is often several yards square between these natural cutters; so that the quarriers are obliged to cut out every block of stone they raise. If these were the effects of earthquakes, &c. they would be found as numerous below as above.

In fact, they are the effect of the slow and gradual yielding and falling of the layers of stone closer to one another, after the water was drained out, and induration was taking place; and we find them more numerous near the surface than farther down, because the surface was not pressed at first by the weight of any super-incumbent

bent matter; of course, it would contain more humidity, and retain it longer. When this was by degrees drained away, there would be the more room for the crops or superficies of the strata, to lean, slide, and fall closer together, and their yielding and pressing together above, later than below, must necessarily occasion more cracks or cutters in each stratum at the surface than farther down.

I have endeavoured to be as explicit as I possibly could, in explaining this great and difficult subject, and I have produced all the little examples which I thought most apposite, by way of illustration, and I am sensible that all is little enough.

The subject is so great, comprehensive, and difficult, so much above and beyond human capacity, that although I well understand what I would wish to explain, yet I do not find it an easy matter to communicate my ideas on the subject, so as to be perfectly understood by others. However, I hope, that the candid naturalist will understand me, and not condemn my labour; for although novices in this science should undervalue what I have advanced as wild and inconsistent, I flatter myself the experienced adept will acknowledge that my observations are the fruits of considerable application, much study, and extensive experience. Nevertheless, seeing

the subject is so intricate, I pretend not to unfold the whole arcana of nature, nor entirely to remove every difficulty and objection out of my way. There is one of considerable magnitude, which occurs at present, which I will attempt to remove.

The difficulty I mean is this: In my account of the strata I call regular, which, from their streaked and laminated textures, and their position one above another, &c. have unquestionable marks of being formed by the tides, or in other words, by the flow or current of water in motion. I said that the first of these strata was formed upon what began to be dry land, or where there was but little cover of water, or chaotic matter, at the ebb of tide; and if there were but two or three regular strata in all, this matter would appear very plain and simple; but as we see in some high cliffs of the sea, in deep rocky glens, among our highest mountains, and in sinking deep coal pits, &c. many great and lofty sections of the strata, where we behold prodigious numbers of them in regular order, one above another, it may be difficult for many to conceive whence the great quantity of matter was to come from, which was requisite for composing all the rest, after the first two or three were done by the flowing of water? There are two or three circumstances which contribute their joint assistance to

to enable me to remove this difficulty out of my way.

I suggested before, and I think it was a natural supposition, that the then surface, or what began to be the solid superficies of the globe before the strata were made, was soft and slimy, unequal and full of hollows, and mixed with a great quantity of water. Now, when a prodigious weight of strata in a humid and flexible state was spread out upon such a ground, the water below would be forced out, and the superficies of the globe would shrink down considerably. All the strata, and especially the mountains of sediment, would grow thinner and be squeezed into less room as the humidity was drained out, and the prodigious weight of strata above pressed them together. This consideration helps in part to remove the difficulty started. The globe shrinking by degrees into less diameter, as the weight of more strata was added above, and the humidity drained out, the same height of tide would still spread out more strata. But this is not enough: it yet remains to be enquired, whence all the matter came which composed the subsequent strata? I answer, that part, and only the smallest part, would be carried out by the interior waters, in their violent eruption when they burst their confines. When these waters forced their way out with such prodigious violence

lence as the incumbent weight of a great depth of strata made necessary, when the superior waters had retreated, no doubt, a considerable quantity of stony matter would be forced out with the water, which would contribute in part to form future strata ; but the far greater part of the matter which compose the regular strata, came from the bed of the ocean, which purged itself, by the motion of the tides, of all the sand and earthy matter which was before mixed in the waters, and laid it upon the solid and higher part of the globe in regular strata ; and the ocean does purge itself by the motion of the tides to this day. Though the larger rivers should carry down ever so much sand and slime into the sea, it throws it all out again upon the land.

It is easy to be perceived, from what I have advanced upon this great subject, that I am firmly persuaded the whole materials which compose the solid part of the superficies of our globe, were once entirely mixed with the waters in a chaotic state ; and it appears from all the records of antiquity handed down to us, that this was a received opinion in the earliest ages all over the world. This was the chaos of the ancient poets and philosophers.

No

No doubt this was handed down to them by early tradition ; and it is natural to suppose that some of the wisest of them would examine nature, and finding the phenomena they beheld correspond with tradition, would preserve the memory of it long in the philosophic parts of the heathen world. This early tradition might have been derived at first from some revelation ; but however they came by it, it appears to me very probable, that their first notion of the chaos then was much the same as mine is now, though it was in later times strangely blended with fable and fiction, to countenance their various systems of idolatrous theology. What idea they had of it at last, is not easily conceived.

In the raw and humid state of the superficies of the globe at that time, it is to be supposed that strong and powerful winds would frequently infest the lower regions of the atmosphere, and these might have a powerful effect upon the stratification of the superficies of the earth, and in producing several of the present phenomena we behold upon the face of the globe. If we will suppose that many of these storms of wind were local, and only extended over a small part of the globe at one time, it is rational to suppose that these local storms of wind would have a mighty effect in driving or carrying the stony matter
along

along with the tides, and lodging it in strata in different places.

Perhaps this is the reason that we every where find strata of the same quality in patches, which only stretch over a limited extent of ground, and then others of a different quality take place. But I will not enter into minute disquisitions of all circumstances. I only mean to give the great outlines of this extraordinary work of nature. At the same time, I will just remark here, that in all my perambulations and researches, I have not been able to trace any particular class of strata for any considerable length of ground, comparatively speaking; for two or three hundred yards, and two or three hundred miles, are both of them inconsiderable, in comparison of a zone of the earth. I once took it for granted, as I believe many others do, that every stratum was a zone, or at least reached, I knew not how far; but I afterwards frequently examined circumstances more accurately, in order to put this matter beyond a doubt; and both in Highlands and Lowlands, I found I was wrong; and now frequent observation and experience convince me that there is no such thing as a very long stretch of the same class of strata.

Observations upon the phenomena of the strata which compose the superficies of our globe, is a pleasing and a fruitful subject of investigation, which

which I have long examined, and could say a great deal more about it, were I not in danger of being impertinently tedious. However, before I dismiss it entirely, I will beg leave to make a few observations relating to the course or bearing of the strata.

As I hold that the superficies of this globe was formed by the waters put in motion by the tides, it is necessary, upon this hypothesis, that the bearing of the strata should be due north and south between the tropicks, and that they should deviate a little from this line without the tropicks. On the north side, they should lean or bend a little towards the north-east, and upon the south side, towards the south-east.

That this deviation or bending back of the line of direction, or bearing of the strata, should still continue and increase, as it advances from the equator towards the poles, so as to form an easy sweeping curved line across the semi-diameter of the earth, from south to north, &c. The attraction of the sun and moon upon the superficies of the globe, is greater between the tropicks than without them; of consequence the tides must rise to a greater height at the equator, than in the high latitudes without the tropicks; and as the attraction is greatest between the tropicks, and the tides would rise highest there, so would they run foremost at the equator, (to compare again

again great things with small,) as we see the stream of a swift running river in a flood. The current in the middle of the river is always highest, and bears foremost. But the greater degree of attraction between the tropicks arising from the figure of the globe, and the situation of the torrid zone makes it necessary for the tides to rise higher there, and to run with a forward head, or current; and this would especially happen in the high tides in the chaotic state of the earth; and if the strata, in fact, appear in this supposed line of direction, it is a strong collateral proof that my hypothesis of the formation of the strata by the tides, is true.

I have been told that the bearing of the strata at the equator, is true north and south, of the truth of which report I have not the least doubt, as it appears necessary that it should be so. In these northern latitudes of ours, the line of direction or bearing of the strata, where they lie fair and regular, without being warped or thrown out of their due course by the influence of any particular cause, answers as nearly to my idea of the line of the tide, when the whole superficies of the globe was in a fluid state, as can be imagined; and the strata in all this island, in high and low lands, in mountains and plains, bear to the same point in general. So far we can
trace

trace an exact correspondence between the cause and the effect ; and I cannot help thinking that they mutually prove and illustrate one another.

It has been erroneously asserted by many, that the strata which compose the superficies of our globe are disposed according to the true order of gravitation, the heaviest below, and the lightest above ; but I have disproved this hypothesis in my observations on coal, where I have proved to a demonstration, that the lightest and the heaviest, with all the degrees and mediums, are blended promiscuously in the coal field, without the least regard to gravitation. There we find freestone, till, ironstone, coal, till, freestone, limestone, coal, ironstone, &c. &c. alternately one above another, without the least regard to the laws of gravitation. In constant experience we find the order of the strata run counter to it in the coal field, as we very commonly find ironstone above coal, and every roof of coal whatever is much heavier than the coal itself. There are above thirty seams of coal in the lands of Gilmerton, with a prodigious number of all the various strata commonly found in coal fields, interposed between them. There is not any mark of the order of gravitation in this field. But I need not insist upon this point. It is sufficiently clear ; and in my account of the formation of the strata, one

above another, by the stream or flowing of the tides, there is no room left for the laws of gravitation to take place. If they had taken place, it is highly probable that we should have greatly suffered by it—that iron and lead, &c. &c. had sunk down absolutely out of our reach.

But this affair is better ordered for our accommodation and convenience. An improved state of society cannot be supported without numbers variously employed, according to genius, inclination, skill, and bodily strength. Industry, even when prompted by necessity, has a direct tendency for the good of the common wealth; and the greater the numbers well employed, it is the better for the whole community. Now, by viewing our subject in this light, it must be confessed that the superficies of the globe being stratified, and the order in which these strata are disposed, is exceeding convenient for society. For as the matter stands, we can make discoveries of, and work coal, ironstone, lime, building-stones, mines, &c. In short, every thing is so well appointed, and so properly disposed for the good and convenience of man in a social state; that were he not mortal and vexed with anxiety, and with unruly passions and appetites, and were not the spirit of man always dissatisfied with present enjoyments, and still aiming at something more, this world would be a heaven up-

on earth. But the terrestrial paradise is only suited to gratify the cravings of the bodily senses. The immortal soul meets with nothing but disappointment and disgust in this world; and therefore it instinctively pushes forward its hopes and desires to a state and enjoyments more congenial to a spiritual nature.

In taking a short review of what I have advanced about the formation of the strata, I have the pleasure to reflect that I have not the least doubt of my being right in the main, though I may have erred in some little relative points; and though all the world should refuse its assent at present, it cannot hurt me in the end. I know upon what grounds I stand. All the phenomena of the superficies of the globe above ground and below, are on my side; and in time these phenomena will be duly examined, and the result of the strictest scrutiny which time can produce, must conclude in assent to the truth of what I have advanced.

It would be too tedious to enumerate every circumstance I have examined, and which might be brought forward in proof of my opinion.

The regularity of the strata is clearly on my side; and the irregularities, breaks, and interruptions we meet with, become necessary, upon the supposition of water being the mediate cause

of

of this great effect. When the laminated and streaked beds of stone are broke across, the sections of them present the effects of water in motion at first sight. The several strata, streaks, and lamina, are spread out so regularly the whole length and breadth of the stone, that it is impossible to account for the effect from any other cause, than the motion or flowing of water spreading the matter upon a plane superficies. And what may be called the lesser strata, or curious specimens of stone, discover the same phenomena in miniature, as the great exhibit upon a larger scale.

When a section of some of them is polished, it discovers regular streaks or lamina for a little way, and then this regularity is broken, and the edges of the different strips are split by one another, and yet we see them again in the other end of the stone, and this in miniature is as perfect a slip as we find in the coal metals. In short, by a careful inspection of the inner texture and sections of curious stones, we see that the same work has gone on in miniature as we discover in the great strata, and I believe it will be difficult to point out any material phenomena upon the face of the globe or within its surface, that, upon a careful and thorough examination, shall contradict what I have advanced. I do not think that any thing can be pointed out which is not perfectly

perfectly reconcilable to my conclusions in general, though I may not have closed up every avenue against objections.

I have no doubt I could answer many objections, rectify many mistakes, and clear up many difficulties and dark passages, if they were candidly pointed out to me. It can hardly be expected I should be quite perfect in my first essay upon so great a subject, which is new; at least as far as I know, my investigations are new; at the same time, I am not the less confident that they are true.

I have carried my subject about in my mind more than thirty years, and met with many difficulties in the investigation of some parts of it. Sometimes a single difficulty has puzzled me for years, and when it was removed, a flood of light would rush in upon my mind, which would bring many discoveries along with it, besides the clearing up of that one point; and then I would perceive the cause of my perplexity to be so simple, that I have many times wondered how it could be any difficulty at all. Many fatiguing journeys and perambulations I have made to examine how facts agreed with my reflections, and was often mortified with disappointments when my reflections were in a wrong track. Notwithstanding, I still persevered, and I always found that time, assisted by observation and reflection, still gave

gave new acquisitions of knowledge, and advances in knowledge and experience were always the means of removing difficulties, and of clearing up dark points.

Besides the many voluntary perambulations and researches I have made, in order to bring difficult points to a satisfactory conclusion, my proper business was often very serviceable in furthering these enquiries. But though I carried my subject always in my mind, and embraced every opportunity of making observations, I never pretended to communicate my thoughts upon it, until I had removed every difficulty out of my way. The whole horizon is now clear before me, and the conviction of truth shines bright through every part of my subject.

Now, such a fabric as this cannot be easily overthrown. It cannot be overthrown at all, although the loudest winds should beat against it. If it meets with opposition, so much the better. Opposition will promote enquiry, and impartial enquiry will ultimately determine in its favours.

III. I shall now proceed to examine part of the modern system of Monf. Buffon, &c. to see how it corresponds with the real structure of the superficies of our globe.

In

In the discussion of this third general head of these enquiries, I will not take the trouble to turn over the modern system or theories of the earth, in order to examine all their positions. Such an undertaking is too tedious for me, and is quite foreign from my plan, which is to communicate my own observations in travelling through the mineral kingdom; and therefore, I will content myself with examining some of their general doctrines, and comparing them with the structure of the superficies of our globe as explained above, which is known to every intelligent naturalist to be a true account of the matter.

“ The earth (say the modern philosophers) grows old, like a mother no longer able to bear; but new earth (say they) emerges out of the ocean, fresh and vigorous, fit to bear and nourish plants and animals for some time, and then it sinks again.”

Wild as this hypothesis really is, it must be acknowledged, that when it is attended by all the arguments which they have adduced in support of it, it appears at first sight to have some shadow of truth on its side, but these shadows are illusive, and conceal the real truth from our view. The mother of a season grows old,

it is true, and can bear no more ; but the mother is renewed in the daughter, who bears in her turn, and so the race is continued. The earth receives annual supplies of soil equal to the waste, from the decomposition of the superficies of the strata, from the fall of the leaf, and the decay of all vegetables ; the seasons renew her youth, and prepare her to bear again with new vigour.

We know very well that Greece, Italy, and many other countries, which were once like the garden of God in fertility and beauty, are now comparatively barren and desert ; but it must be remembered, that those fields were green and fertile in the flourishing state of society in those countries ; whereas now tyranny, horrid tyranny, reigns there,

Let us view this subject nearer home. How many extensive tracks of land in this island lay waste and desert in the time of the Saxon Heph-tarchy, during the contests between the houses of York and Lancaster, and the longer contests and mutual invasions of the English and Scots before the Union, which are now green and pleasant fields, producing rich and yellow harvests, and adorned with gay and beautiful villas, commodious farm-houses, and populous towns. It is divine industry, attended and assisted by divine philosophy, when enjoying the blessings of peace
and

and commerce, that enriches and adorns the face of the earth, that by the wise and liberal application of manure, and of alternate labour and rest, give her all the vernal bloom of the gay and youthful virgin, and the more ripe and perfect charms of the nursing mother ; witness the wonderful revolution in the state of agriculture in this island since the Union.

When Greece, Italy, &c. flourished in verdure and fertility, industry and the arts, philosophy and commerce went hand in hand, which encouraged population, and they were encouraged by internal peace and liberty. In a flourishing state of society, under a mild and peaceable government, and wholesome police, industry and the arts reign triumphant, and every worthy member of the community pays them that true homage and respect which their real excellence deserves. In such a state of society, every person endeavours to make his fields as rich and fertile, and his habitation as commodious and pleasant as possible ; and the fruitful all-teeming earth answers his expectations, and rewards his labours, when liberally assisted and prudently managed. But, on the contrary, when countries are desolated, and continue under the baneful influence of tyranny and bad police, the best fields are soon choked in their own fertility, the

rich champains become putrid marshes, the green and pleasant meadows are overflown and fanded by inundations from the mountains, which before were kept within proper bounds. The higher grounds, and naturally poorer soils, return to their ancient state for want of proper culture and manure, and all the face of nature assumes a melancholy aspect of desolation and barrenness. But let the scene be shifted again. Bring industry with all her friends about her upon the stage, and the ensuing acts will be more glorious and satisfactory: Happy revolutions shall succeed one another, and the whole conclude in fertility, plenty, beauty, and joy.

It is a known fact in agriculture, very well ascertained by experience, that the soil, so far from diminishing and failing to bear, on the contrary, encreases under the hands of industry, both in bulk and fertility, when managed with liberality and skill. The greedy churl may reap often where he does not spread his manure, and if he does, his fields will punish him, by refusing the succeeding crops they are not enabled to bear. But bad management is no rule by which to judge the fertility of the earth. She increases in richness under good management, and still produces plentiful crops, and will continue to produce so long as she is managed with industry, prudence, and justice.

Let

Let us thoroughly consider the force of these observations. They will bear examination by every test, and if that attention is paid to them which their importance deserves, they will amount to a clear proof, that there is no occasion for the change of the earth contended for. But that we may do all justice to Count Buffon, and the other favourites of the new philosophy, let us, in the next place, examine the matter of fact, which requires our most serious attention, as there are many converts to the belief of this doctrine of the new philosophy; and it must be acknowledged, that some of the phænomena of nature seem at first sight to countenance and confirm their faith, but it is only at first sight; when we come to look into facts, and to examine these phænomena to the bottom, we find, that the conclusions drawn from them are not only demonstrably false, but that they are also big with the greatest absurdities, and infer consequences which are absolutely contrary to nature,—which are repugnant to her known laws, and contrary to experience. But let us examine circumstances, and in so doing, it cannot be denied, that the ocean between the tropicks, and near them on both sides, has a strong current from east to west; and it must be acknowledged, that this current has a considerable

able effect upon the eastern rocky shores in those latitudes, and in higher latitudes further to the north and south; wherever the tides set in strongly towards the land, the ocean has in a degree the same effect upon the rocky shores of the continents and islands. In this investigation of the subject, it is very evident, that these tides and currents have very powerful effects in wearing down and gaining upon the rocky shores of the continents and islands.

Where the rocks are either soft, or of a lax and open texture, their exposure to the action of the air, and the powerful beating of the waves, washes them down by degrees into small grains and particles.

Where they are more hard and firm, and of a strong cohesive quality, the violent dashing of the waves make way into some softer veins and fissures, which by slow degrees undermine and bring down the hardest rocks, and then the fragments are rolled and agitated in the waters, and by trituration and friction one against another, these fragments are also worn down at last into grains or sands.

It is also very evident, that many inland rocks, by being exposed to the action and changes of the atmosphere, by degrees weather, decompose, and fall down into grains and sands; others are undermined

undermined by the currents of rivers, rivulets, and lakes, which brings down fragments of them, the debris of which is worn down to sand, by the motion of the rivers, &c. as effectually as upon the shores of the ocean. The sides of mountains, and all the lower hills, are furrowed with innumerable rills of water, all of which have very strong currents in rainy weather, and especially after the melting of snows; and the inundation from the mountains and lowland floods, carry great quantities of sand and mud in their mighty currents to the ocean.

Thus far circumstances are in our sight, and they may be easily and truly investigated by every intelligent enquirer; and hitherto I agree with M. Buffon, but no farther: I can walk with him no longer, as the path he now chuses leads to a land of darkness, which is full of "gross chimeras." The conclusions he draws from these known and acknowledged premises are not true, and they infer many consequences which our experience of the phenomena of nature assures us to be absurd and false. He says, "that the
 ' mountains and all the higher grounds melt
 ' down entirely by degrees, and that the sand
 ' and other spoils of the mountains and of the
 ' rocky shores are carried by the waters, and
 ' spread over all the bounds of the ocean, and
 ' that they subside in the waters, and form the
 ' several

' several strata in all parts of the bed of the
 ' ocean, as we behold them upon the superficies
 ' of the earth: That the dry land which now
 ' appears was, in some ancient ages of the world,
 ' the bed of the ocean, and that what is now
 ' dry land will be under the ocean again in fu-
 ' ture ages, and *vice versa*, what is now ocean
 ' will be dry land: That not only the several
 ' strata of different thickness and qualities, and
 ' all the other phænomena we discover in the su-
 ' perficies of the earth, are formed under the wa-
 ' ters by this supposed subsidence, but also that
 ' by the currents and other motions of the wa-
 ' ters, mountains, and valleys, and all the phæ-
 ' nomena we behold upon the superficies of the
 ' globe, were formed under the waters of the
 ' ocean, and that the like are now forming for
 ' some future dry land." I will go a little far-
 ther in my concessions, and own, that all this ap-
 pears plausible enough at first sight, to such
 as take for granted any hypothesis that pleases
 them, without examining facts. But, however
 plausible the above conclusions may appear at
 first sight, when the circumstances concerned are
 well examined, we find that they are not true.
 The sand, &c. brought down from the moun-
 tains, and worn off the rocky shores, are not
 carried out and mixed with the waters through
 all parts of the ocean, in order to be formed in-
 to

to strata by subsidence; on the contrary, the sea purges itself of the waste of the rocky shores, and by that means the sandy shores are formed; and the sandy shores are the most effectual and most durable barriers against the ocean, to prevent its making any further incroachments upon the land. When once a sandy shore is effectually interposed between the ocean and the rocks, the rocks are for ever after preserved from any further injury or encroachment from the waves, as the sands always increase in some slow degree, unless there is a strong current in that place running parallel to the shore. Some of these currents, it is true, carry sand, &c. frequently a great way; but then the matter so carried by currents is thrown out upon some near or distant shore, where it contributes to form sandy, or slimy ground, and increases the dry land.

M. Buffon asserts that streams of water always continue to carry down the dissolved strata, and to lodge it in the bottom of the sea, until the land is worn down as low as the bed of the ocean, and that when matters are in this state, the change is facilitated, the waters soon invade the dry land, and overflows it, and then new land emerges out of the ocean: And he further asserts, in support of this hypothesis, that all mountains are narrow ridges, or peaked at the top, which he says is a proof of their rapid advance towards this change.

I have already acknowledged that a considerable quantity of sandy and slimy matter is carried down by the streams from the mountains; notwithstanding, if we examine the subject thoroughly, we shall soon discover that this is altogether but a trifling, unequal process, no way proportioned to the subject, and that no such tremendous catastrophe can be concluded from it. It is not true that the summits of all mountains are peaked or narrow ridges. The extensive plains of New Granada in South America, are higher above the sea than the summit of Teneriff. The country of Abyssinia in the old continent, is near as high. Several other countries in many parts of the globe, especially between the tropicks, are higher above the sea than the summits of any of our neighbouring mountains; and can we call any of these narrow ridges? Some of these elevated countries are some thousand miles of extent, and many of them stretch several hundred miles every way, which removes them far from the idea of narrow ridges; and these few instances are sufficient to shew us that M. Buffon has not represented the matter fairly. The highest mountains in Scotland are so far from that description, that they have generally very broad summits; and moreover, contrary to what M. Buffon and others

others assert as matter of fact, generally the highest parts of the highest mountains are the hardest.

Bineves in Lochaber is certainly the highest mountain in Britain. The summit of Bineves is broad, and the rocks upon the summit of it are so hard and tough, that I know not to what to compare them, excepting that wrought iron may come up to them in strength and cohesion, but it is far short of them in hardness. Now a hundred thousand years can be supposed to have but a very small and imperceptible effect upon this mountain; and many others are nearly of the same description as this.

With respect to the small quantity of matter that is carried down from the sides of the mountains by strong currents, it bears no proportion to the effects assigned. But the friends of this hypothesis may ask me what becomes of it then? If I will not allow that strata were formed of it in the bed of the ocean, how can I dispose of it? I answer, that it is all well and wisely disposed of for the benefit and advantage of the present earth, and the inhabitants of it. Part of it is lodged in lakes, and in deep unseemly gulphs, in the course of the rivers, which are improved thereby into rich and pleasant valleys and plains, and the residue is carried along by the floods, to the borders of the ocean, where it is very happily disposed of

to form new land, which in fact enlarges the bounds of our habitations, and in time becomes the most useful, the richest, and most convenient parts of the earth for society and commerce. Great numbers of magnificent friths, extensive bays, long inlets and arms of the sea, have been filled up by the waste of the mountains, which are now improved into rich and plentiful countries; and upon which are built many flourishing towns and cities, which enrich those countries by the extensive commerce carried on in them.

These are your glorious fat valleys situate contiguous to the seas, and many of the rivers which formed these valleys are now confined in deep and narrow channels, fit for the reception and safe passage of tall and wealthy ships from all quarters of the globe; and upon their banks are seated some of the most flourishing commercial cities in the world, which are the scenes of art, of industry, plenty, and wealth, and where industry and commerce contribute to the wealth and convenience of the world.

Rivers carry down more or less of earthy matter in proportion to their magnitude, and the extent and figure of the superficies their waters are collected off. Great rivers, which have their sources in mountainous countries, carry down great quantities of matter to the valleys, and to the margin of the sea; and especially, if those
mountains

mountains abound in schistus, and other argillaceous strata, which are apt to decompose and dissolve into small grains and particles ; but then it must be considered, that this waste of the mountains diminishes in proportion as the softer soils fail, and the harder come to be chiefly exposed to the weather and the currents, and in proportion as the channels of the currents become more level and equal ; so that in the course of time there shall very little come down with the waters. I have seen rivers run clear when greatly swelled with rain ; and as the countries they rise in and pass through become more plain and level, they will at last cease to carry down any more.

When great and weighty rivers, which are apt to be greatly swelled by inundations from the mountains, pass through extensive desert woodland countries, they frequently tear up numberless trees by the roots, which are carried down by the waters, root and branch ; and these, when they arrive at the flats, are often intangled in one another, and lodged heaps upon heaps in all directions across the stream, which sometimes choaks up the channel of the river, and turns it out of its former course to one or both sides ; and extensive lakes and marshes are frequently formed thereby ; sometimes in large plains which the rivers pass through, but more frequently near the mouths of the rivers ; and the lakes and marshes
are

are by degrees filled up with new matter, brought down by the rivers, which in time becomes rich and excellent soil. There is also a great quantity of sand, mud, and rubbish carried by strong rivers quite into the tide, and the tide throws it back again upon the land. A high tide, with a strong wind from the sea, and at the same time a great land flood, which frequently happens, often throws up great banks of sand and rubbish upon the bars in the channels of the rivers, and on both sides upon the shore, without the bars, which choaks them up, and forms large lakes and marshes upon ground that was before possessed by the salt water ; and these are likewise filled up in time by slime carried down the streams, and so the dry land is enlarged, and still continues to be enlarged, so long as a sufficient quantity of matter is brought down by such streams from the higher grounds ; but I deny that any part of it is carried out to remote parts of the ocean, and there lodged in sediment. The strong currents of some weighty rivers, it must be owned, carry sand and slime a good way out from the shore ; and this is not always, and in all places, wholly thrown back by the tides upon the same shore, but strong winds, and especially strong currents running parallel to the shore, frequently carry some of it to a less and greater distance, but then it is assuredly thrown out by the tides upon

upon some near or distant shore ; for I constantly affirm that the sea purges itself by the motion of the tides of every thing thrown or carried into it, excepting only in these two cases :—1st, When masses of metal, or other ponderous bodies, are too heavy for the motion of the tides to move from the bottom :—And 2d, at a meeting of two or more tides, the sands, &c. frequently accumulate in large banks, which sometimes rise so high as to form the basis of islands. Belgia, the neighbourhood of Alexandria, in Egypt, and many other places, are clear proofs of the great and extensive tracts of new land formed at the mouths of great rivers ; and the Carles of Gowrie and Stirling in Scotland, are small, but valuable examples of it at home.

Geographers and observing travellers are full of their accounts of new land increasing where great rivers disembogue their currents. What encroachments must some of the great rivers of Africa and America make upon the borders of the ocean ? Some of these have their sources in a thousand hills ; and their deep and weighty currents flow several thousand miles in length. But I need not multiply instances, either in proof or illustration of a fact so generally known and received on all hands. And this fact, so generally known and acknowledged, is a sufficient proof, indeed an ocular demonstration, that the matter
brought

brought down by rivers is not carried out through the bounds of the ocean, and lodged in strata, in order to accomplish a chimerical change.

We need not have recourse to such whimsies to account for the progressive operations of nature. They are more simple and rational, and of easy investigation, if we will thoroughly examine all circumstances. The Delta, and many other great plains formed, and now forming near the sea, in many parts of the globe, makes this matter abundantly clear.

In the cursory survey I have taken of the progressive operations and changes on the superficies of the globe, we see nothing that either requires or indicates such a catastrophe as the modern philosophy contends for : On the contrary, the result of our enquiries makes it appear evident, that all the change which really happens, is by much for the better, and altogether in favours of the present earth we live in ; which shews us that a wise and benevolent providence superintends and disposes the minutest operations of nature for good. The high and inaccessible mountains, which are immerfed in the clouds, and in the cold and frozen regions of the atmosphere, are penetrated and decomposed by the changes of the air and weather, and washed down by the rains and melted snows ; and the matter carried down by the floods is formed into new land, more level,

vel, useful, and commodious for man and beast. The coarser grains, and hard, sandy particles which swim deepest in the streams, lay the foundation, and the more earthy slime is spread out to enrich and fatten the plains and valleys: and it is worthy to be remarked, that this new land is gradually made, as the progressive advances of society has occasion for it; and it is made in situations the most commodious for society, viz. in the fat valleys and plains, upon the banks of great rivers, and near the sea; in the midst of plenty, and convenient for increased population; for improvement and increase of the arts, manufactures, commerce, and wealth. Many, I had almost said most of the greatest and wealthiest commercial cities in the world are of this description. They who cannot see, and will not acknowledge a wise and benevolent providence in this, are wilfully blind.

Let us now look a little into the consequences of the superficies of our globe being formed by subsidence in the bed of the ocean, as supposed by the new philosophy; and whoever examines this hypothesis with candour and impartiality, must confess that he can discover no traces of that useful diversity, order, and regularity, which we every where find in and upon the superficies of our real earth. If the rocks and strata which compose the superficies of the globe, were to be formed

ed by fufidence in the bottom of the ocean, we fhould have nothing but one uniform mafs of ftony matter, compounded of grains and particles of all colours and qualities, without the leaft diversity or appearance of ftratum, fiffure, or breach of any kind whatfoever. It is neceffary and agreeable to the nature of things, that in fediment in water, all particles, of whatever qualities or colours, contained or fufpended in the water, muft fubfide next, and be blended through the whole mafs, in as abfolute a compound as wheat and rye flour in bread, when they are both ground together in the mill. There is not, I think, in the laws of nature, or in the compafs of our reason or reflection, any thing that can be opposed to this, excepting gravitation; and if we will fuppose that the laws of fpecific gravity take place in this fediment, where it is more likely to take place in perfection than upon any other hypothesis I know; in that cafe we muft fuppose and expect, that all the metallic and moft ponderous ftony particles, would be funk loweft down, and the lighteft would always be uppermoft; but we do not find it fo in experience.

Nevertheless, to give the hypothesis all fair play, let us fuppose the matter to be fpread out in the waters, and to fubfide in a continued fucceffion of time; and this will only increafe the confufion.

The

The heaviest particles have still the tendency, and they have abundance of time allowed them to sink down lowest, and the next in weight would press hard after them; and others, in their own order of gravity, would follow close upon the heels of the former, which in the end must produce a compound mass, uniform and solid throughout, without the least symptoms of, or inclination towards any of those horizontal divisions which we call stratification. Upon this hypothesis, we should have no distinct layers, or strata; and therefore, of consequence we should have neither freestone, limestone, nor any other of the various strata which are now so very convenient and beneficial to society; but, instead of this useful variety, all the rock would be one uniform mass throughout, composed of particles of all qualities. In this case, all our rock would resemble the largest granite rocks. We need not pretend to say it might happen otherwise. The known and received laws of nature forbid it; and our granite rocks, which were in some respects a sediment, are an ocular proof and demonstration that all the rocks would be an uniform compound mass, as I have represented.

Let any man examine a mass of granite, and a hill of granite, which is only a large mass without any bed or division, either horizontal or perpendicular, in which mass or hill, all the grains

and particles which compose the granite are entirely commixed, without order, through the whole body of a small mass, and likewise through the whole body of the mountain. I saw at Bineves, in the Highlands of Scotland, whole mountains of granite, of about twelve hundred yards of perpendicular height, which appears but as one uniform mass of solid stone from top to bottom: and it is out of nature to suppose that rock formed by sediment under the ocean, could be any thing else than an uniform mass throughout, like the granite; and of consequence, upon this hypothesis, we could have no limestone, or freestone—no building stone of any kind—no slate, or marble, nor any other curious or valuable stone, for use or ornament—we could have no seams of coal, strata of ironstone, nor any other mine or fossil we now enjoy; but instead of our useful and curious variety, we would have but one uniformly solid mass of rock spread out over the whole face of the globe; and as we should discover in it no sort of division, fissure, or opening of any kind, it would never come into our heads, to cut into such an uniform and boundless mass of stone, any more than it comes in our heads to dig into one of the northern mountains of ice. In fact, we should, upon this hypothesis, have nothing to dig with. Iron, &c. would be far out of our power, dispersed in particles through the whole mass.

Almighty,

Almighty, wise and benevolent Creator! how excellent are thy works!—how convenient for needy man!—how suitable to answer the designs of thy providence!—in wisdom hast thou made them all!

I have already made it evident, that upon this hypothesis we could have no strata or horizontal divisions of any kind; and I am next to shew, that there could be no perpendicular fissures, nor chasms in the superficies of the globe; and of consequence there could be no veins or beds of metal, or of metallic ore in any accumulated or collective body, as we now find it; but on the contrary, the metallic, and all other mineral particles must be dispersed through the whole body and composition of the mass of rock.

There could be no perpendicular fissures nor chasms in the superficies of the globe, because subsidence in water, and which continues constantly under water untill the rock is consolidated, has no opportunity nor possibility of any parts of the rock shrinking into less room by the humidity evaporating, or any way draining out of the mass; but the particles of matter would gradually sink downwards through the water, and insinuate themselves to fill up every cranny and pore in the superficies of the subsiding mass, and the water would be gradually excluded and give place to the heavier particles of matter

an

and these more ponderous corpuscles would press and adhere closer and closer, gradually and uniformly, by their own gravitating property, and by the equal uniform pressure of the superincumbent weight of the superior waters, which at once press equally on all parts, and sustain the whole mass equally in all parts, so that no part can yield or give way on any hand, as there is no void place, or weak side to which it could yield; all the parts being equally full, and equally sustained by the surrounding and superincumbent waters. I have frequently seen extensive pieces of sediment, where water has been drained off by art or accident, and the whole mass of such sediment was always found equally whole, smooth, and found in all parts, without the least aperture, crack, or opening whatever, until the water is drained off; and then when it is no longer pressed and sustained by the incumbent waters, it soon begins to yield on all hands, and to discover chaps and gashes, partly from the loss of humidity, as the water drains out, and partly from the yielding of several parts of the mass towards the lower and weaker sides.

Many of our granite rocks which were formed by a hasty subsidence, exhibit exactly such a mass, and such superficies, as I suppose, rock formed by subsidence in the waters of the ocean, must

must necessarily have, with this only difference, that when the granite rocks were really formed by subsidence, they were soon laid dry by the retreating of the tides, and of consequence, they would chap in some places, as the moisture was strained out. Accordingly we find there has been such chaps and fissures in the granite rocks, some of which were afterwards filled with foreign heterogeneous stony matter of a different quality, brought by succeeding tides, and some of the fissures and chasms were filled with mineral matter. Such are some of the mines of Cornwall, found in the muir-stone or grey granite; and such are the lead mines of Strontian, in the Highlands of Scotland, &c.

This chapping of the surface of rock formed by subsidence, must necessarily take place, if it is either alternately wet and dry, by the falling away, and return of the tides, or when wholly laid dry by the water entirely retreating from it, while the stony matter retains any humidity before it is perfectly consolidated. But this could not possibly be the case in M. Buffon's change of sea into land, as the advances there would be so very slowly made, and would be accomplished in such prodigious distant periods of time, that the rocks must be as effectually consolidated before they were laid dry, as they would be to eternity; and therefore no room would be left for any change
in

in the superficies of the globe. Nothing in this case would be found, but one universal sheet of rock covering the whole face of the globe, as solid, uniform and unbroken, as a sheet of ice covers a pool of water, during the extremity of a hard frost; nor would it ever be broken, as mankind would have no metal to make tools to pierce it with, the mineral particles being all either mixed throughout the general mass, or subsided too far below the surface; nor could it ever suffer any violence from below by volcanoes or otherwise, there being no room left in the general sediment for any veins or lodgments of the pyrites and other combustibles, nor any room for the admission of air or water to disturb or ferment them.

In short, in this supposed sediment, a complete uniformity would absolutely and universally exist over all parts of the globe; which, perhaps, might do well enough for a parcel of sensitive inhabitants, creatures who have no wants, but live on the herbs of the field, and lay them down and sleep, without the necessity or inclination for any shelter. But for a mixed creature like man, who is exposed to many wants and much wretchedness, which he is inclined to mitigate and provide for, by the industrious use of reason and the aids of society, to such a creature it would be but a very sorry and unsuitable habitation.

What

What could we do in a world that produced neither coal nor iron, nor any other metal,—that produced no stone of any kind, either for houses, harbours, or pavements, &c.? Our coal, stone and iron, with the other metals, are of such vast use and importance to society, that the bare naming of them in the forging, building, manufacturing, commercial island of Britain, is sufficient to place them in an eminent point of view in the estimation of every intelligent person within the island; and moreover, in our earth, the very interruptions, breaks and fissures in the strata, are so far from being blemishes and useless deviations from regularity, that they are of the utmost consequence to society, to the arts, and to commerce. They are the store-houses and repositories of mineral and metallic ores, without which, we could do nothing in our present state, but eat berries and other spontaneous productions of nature, and then lie down under the next tree. Thank God we are better provided for:—We are richly provided with all that is necessary and convenient to relieve our wants and alleviate our miseries; and therefore, let us rest satisfied with our ample provision, and with the real œconomy of the indulgent providence of Almighty God, who wisely directs all things for good, and we need not dream of any real changes in this world. We have seen that all the partial changes that happen
are

are valuable improvements, and seasonable ones too, both in time and place, as they give additional tracks of new land in maritime situations, as the advanced state of society and of commerce have a demand for it.

Upon reviewing these observations, it evidently appears, that there is no occasion for a change of the superficies of our earth, and that in reality no such thing happens. If we manage what we have properly, it will not fail us,—it will encrease in richness and beauty under our hands, and that for ever, nor would another answer our purpose half so well. We have seen that the imaginary earth formed by our new philosophers would not answer our purposes at all, and therefore we may safely draw this conclusion from our observations; namely, that blind chance brings about nothing worthy or useful for the emolument of man. The wisdom of omniscient providence is only adequate to furnish a world for the accommodation of rational creatures. The wisdom of man is unequal to the task of creating or improving worlds, though a thousand Alphonsos should find fault with this, or a thousand Buffons contrive new ones.

IV. I now proceed to the fourth general head, under which I shall treat of the natural history
of

of mountains; their structure, internal and external phænomena, and the glens and excavations which belong to them.

The various phænomena of mountains have greatly puzzled the naturalists of all ages, and some of them have given to the world many absurd and ridiculous conclusions, relating to the natural causes of these phænomena. I confess that the subject is too magnificent for my handling; however, as I have spent a considerable portion of my time among the highest mountains in this island, I will set down a number of facts, and make some observations and remarks relating to them, which have not been noticed by others.

Bineves in the Highlands of Scotland is unquestionably the highest mountain in Britain. When I was first upon the top of this mountain in a clear day, my mind was overwhelmed in amazement at the vastness and singularity of the prospect around me. When I turned my eyes westward, perhaps no man who has not been there in a clear day, ever witnessed a prospect more full of real sublimity and grandeur, yet highly pleasing and agreeable. I could then see most of the Hebrides or western islands of Scotland, which, with the head lands and promontories of the main, were so curiously interspersed

and blended with the waters, that it is past my description.

To the north was a stupendous congregation of grey and naked rocks of great height and extent, with here and there a lake sunk deep among the rocks. To the east, was a range of great and lofty mountains, of a hundred and fifty miles, reaching all the way into Aberdeen-shire; and to the south, were the magnificent mountains of Perth and Argyle shires, an extent of near a hundred miles every way, and the loftiest in the island, excepting the one I stood upon. When I looked down upon the prodigious assemblage of mountains that were then jumbled together in the extensive prospect before me, I could not wonder that such philosophers as had neither skill nor opportunities to examine all the phenomena of the mountains, should imagine that this globe is nothing but the mighty confusion and broken ruins of a more fair and regular world.

At first sight, such vast, prodigious, seemingly broken, and unaccountably irregular accumulated confusion, such bare and rugged rocks and frightful precipices, I acknowledge, might suggest the idea of mighty fragments, to such as are unacquainted with the phenomena of the structure of those mountains. I cannot blame them for entertaining such an idea; but the presumption of

of such novices, in taking upon them to sit down and write theories of the earth from such cursory, imperfect views, and false conceptions of things, astonishes me.

Is learning and fine parts a sufficient sanction for imposing falsehoods and absurdities upon the world, or a sufficient excuse for attempting to explain what they do not understand? I hope to make it clear and evident, in the prosecution of my enquiries upon this subject, that every thing is as it should be: That the exterior and interior phenomena of the mountains, are the real and necessary effects of natural second causes, which causes I will attempt to investigate and explain. In fact, I find at least more extensive marks of regularity in the structure of these mountains than in any of the plains. But no comprehensive view of this great subject will do. We must enter into a much more minute investigation. Those philosophers who acquire distinguished degrees of knowledge in any branch of natural history, accurately examine the smallest parts of their subject. I will endeavour to follow their example, and I flatter myself, that my history of the mountains will be satisfactory, and convincing to every unprejudiced naturalist.

In the prosecution of these enquiries, I will,

1. Examine

1. Examine the interior and exterior structure of the mountains.

2. I will make some enquiries about the original formation of mountains. And

3. I will examine and explain the external phenomena of the mountains, and of their glens and excavations.

Agreeable to the method laid down, I am

1. To examine the interior and exterior structure of the mountains.

I have before mentioned the hill of Bineves, and took notice, that the greatest part of it and of the contiguous mountains round about it, are composed of fine granite or porphyry. Bineves is about a mile in perpendicular height, and is the king of a magnificent pile or cluster of mountains in the country of Lochaber and shire of Inverness.

More than two thirds of the height of this mountain is composed of a most excellent and elegant red granite. What a treasure would this have been in ancient Egypt, Babylon, or Rome! What a treasure would it now be near London or Paris! Columns and obelisks of any
size

size and height might be cut out here, and the moderns might procure any ornaments they could fancy, as this exceeds every other stone for elegance, beauty, and duration.

I hinted before, that the granite or porphyry of this mountain is all as one mass, without any appearance of strata, division, or fissure of any consideration; and this whole mass of granite is so regular and uniform throughout, that it exhibits not the least mark or indication of strata.

But notwithstanding the uniformity of the basis, and the great bulk of this mountain, the summit of it is, nevertheless, regularly stratified with a different stone, to about one fourth of the whole height: And it is worthy of remark, that contrary to the bold, but premature assertions of Count Buffon, the hardest rocks in this mountain are the highest. Granite is well known to be a hard stone. There is in a deep gulph at the bottom of a frightful precipice, about five hundred yards on the north-east side of this mountain, a smooth and solid pavement of fine granite; and as a convincing proof of the superior strength and hardness of the strata upon the summit of Bineves, there is below a fragment of several tons weight, which fell from the height of the precipice upon this solid pavement. It must have fallen about four hundred yards of perpendicular height; and as it lighted upon a hard
pavement

pavement of rock, it is natural to suppose, that it would be dashed to pieces by its own weight, but on the contrary, it is whole and entire.

This great fragment is of an angular figure, and it fell upon one of its corners, which is only a little marked, but it has bruised the face of the solid granite rock with a much more indelible scar.

The precipice I mentioned upon the north-east side of Bineves, exhibits a magnificent section of the inner structure of that mountain, in which we distinctly see where the uniform mass of granite ends, and the stratified rock begins to ride above it. We also see, that the strata of different rocks dip towards the south-east with an easy declivity.

I have perambulated and carefully examined almost all the deep glens and hollows among these mountains, and there are no higher mountains, nor any hollows or gulphs so deep in any other part of Britain; and contrary to what is commonly imagined by the most of naturalists, who do not attend to all circumstances relating to this subject, there is a surprising and uncommon degree of regularity among these mountains and glens.

This is the most rainy country in Britain, perhaps I may say in Europe. The mountains in general are very high in this country, and the
glens

glens and hollows between them are exceeding deep ; of consequence, the sides of the mountains must be very steep, and of great length from top to bottom. The constant heavy rains have furrowed the sides of the mountains with numberless gutters and gullies, all of which are washed clean by the heavy rains. The rivers and larger rivulets also run upon the bare rock, in all which I could distinctly examine the structure of these mountains, and I declare that I never saw more regular strata.

There are generally fewer breaches and interruptions of the strata, and the declivity is more uniform and regular here than in the lowest planes I have examined ; and with respect to the continuation of the same class or assemblage of strata in the line of bearing, I have as yet seen none so regular, or that stretched so far. The rocks appearing bare in many places, and the numberless rivers and rivulets which cut and traverse these mountains in all directions, enabled me thoroughly to investigate the position and bearing of the strata. I have a hundred times traced a particular class or assemblage of strata down the side of one hill in the rivulets, across the river in the bottom, up the rivulets upon the other side of the hollow, and so on for miles, and found them commonly unbroken and regular.

I have, in that country, traced a particular class of strata in that way, for near two hundred miles upon the bearing, which is nearly from north-east to south-west, and found both the bearing and declivity surprisngly regular, even more so than ever I observed in any low country for half the extent. I will afterwards explain the reason of this regularity.

It is very worthy of remark, that the strata of these lofty mountains, which I have observed to be so very regular, generally decline with an easy slope towards the south-east, and rise towards the north-west, which I suppose was exactly the course or run of the high tides in the chaotic state of the earth, which argument remains in part to be explained; and I have observed in very many places, that this, in general, is the point to which the strata decline or dip, all over this island, which is a strong proof of the truth of my History of the Formation of the Strata, by the flow or stream of water.

There are a great variety of strata, of different qualities, to be seen stretching and declining so regularly through these extensive mountains: Such as several species of argillaceous strata, of schistus, and of slate, some of which is exceeding fine; several species of limestone, of which there is a great quantity in this country, and some marble. The micaceous mountain rock,
and

and the regularly stratified, hard, granulated, sugar-loaf-stone, which was before called a white and light grey quartz rock, from its being composed chiefly of minute quartz grains. Extensive rocks of mill-stone gritt, composed of hard, fine, sharp, and pretty large grains of various colours. This rock is strong, sufficiently hard, the composition of sharp grains being perfectly well cemented : It is very regularly stratified, and would rise in beds of any thickness, and could be cut out of any size wanted. In short, this rock only wants to be known, and a little better situated, to be a valuable acquisition to society for mill-stones. I saw this rock by the sea-side at Lochbroom, upon the south side of the Forest of Coygach ; I also saw it upon the south side of the Salt-Lake, or arm of the sea which separates Arasaig from Moydart. I examined the quality and texture of this stone at Coygach, and am persuaded, remote as its situation is, that it would be worth the while for those concerned to have a quarry opened, and some mill-stones cut out ; for as there are good harbours near the rock, and vessels go there frequently to the herring fishing, they might be brought away to Glasgow and other places, at an easy expence. Besides these mentioned, there are other stratified rocks in these mountains, but this is a sufficient specimen of the regular strata. There are also extensive rocks of granite and breccia,

which are not stratified, and the granite especially is very extensive in these mountains. Although the granites and breccia are not generally stratified in this part of the Highlands, they nevertheless preserve the same course of bearing as the other strata; I cannot say regularly, but rather irregularly. They are indeed as regular as any perfect strata in the line to which they trend, but they are not regular in that line, as they are frequently thicker and thinner; sometimes swelling to the magnitude and height of a mountain, and a mile or two forward, dwindling away to almost nothing; and further forward, swelling out again, in the same line, as I formerly observed of some of the mountain limestones; and there are other rocks and strata among the mountains, which grow thicker and thinner in the line of bearing, and yet preserve the line in general.

I think I have been sufficiently explicit in explaining the origin or interior structure of the mountains, and have made it abundantly evident, that, however rugged and unequal their appearance is without, all is fair and regular within, which at once knocks on the head the idea of ruins, and likewise of internal inflations, and other whimsical accounts of their formation.

There

There are as clear, distinct, and unquestionable marks of the mountains being formed and stratified by the motion of the tides, as of any of the valleys or coal countries; and if any one shall question the truth of any thing I have advanced about the regularity of the mountain strata, I am ready to convince him, by shewing all the local circumstances in the country mentioned.

II. I shall now make some enquiries about the original formation of mountains.

As I have thoroughly meditated on my subject, I will attempt the history of the formation of the mountains, with all the plainness and perspicuity I am capable of.

When I explained the history of the formation of the strata in the superficies of the globe, in my second general head, it then appeared to me very evidently from all the phenomena of the strata, and upon the superficies of the globe, that there must have been monstrous high tides at that period. I saw evident marks of such tides, and also saw that it was impossible to explain the phenomena of nature without them; and therefore I was then obliged to suppose that the tides, from some cause or other, rose far above the common height when the superficies of the globe was formed.

Having

Having since perused the Chapter on Tides, in Mr Ferguffon's Astronomy, I there find, in the 297th paragraph, a clear and perfect illustration of this great point.

If Mr Ferguffon were now alive, and was to write a paragraph, and draw a scheme on purpose to countenance my history of the formation of mountains, and of the superficies of the globe in general, it would be impossible for him to add one word to his paragraph, or a stroke to his figure, that would be more to my purpose, than the words and figure I have just now alluded to. When I first read the paragraph, it looked so like being wrote for the purpose, that I was astonished at it. I regret I never saw Mr Ferguffon, nor had ever the least correspondence with him, nor did I ever see his book, till a few years ago, after writing what I have advanced about the formation of the strata ; and Mr Ferguffon has been dead some years.

According to Mr Ferguffon's scheme of the tides, (upon the supposition of the earth being a fluid globe,) it evidently appears that the tides actually did rise several miles higher than the highest mountains in the world, when this globe was in a chaotic state, before the business of forming the mountains and the strata was completed.

When this globe was in a fluid chaotic state, it appears to me more than probable, that the
tides

tides, in following the sun and moon, would then be highest upon the two opposite parts of the globe, which are now the two continents—that the tide did not gradually and uniformly follow the moon westward, as the earth turned eastward upon its own axis in the diurnal motion, so as to be equally high upon every part of this globe, which was in every moment of time opposite to the moon, but that it advanced in great swells, and that each swell would, by its own weight and force, advance a little before the attracting force of the sun and moon, which would bring the power of attraction to act the contrary way for a short space of time, which of consequence would bring the tide to stand at a height upon two opposite parts of the globe for a short space of time: And that before the powers of attraction would begin again to bring the fluid to a motion westward, this globe would be advanced so far east, that the powers of attraction would act so forcibly, as to cause another great swell of the tide, and so on. Now, if we will allow these opposite resting places of the tides to be the two continents, the old and the new, we then have what we wanted, to enable us to account rationally for the phenomena of the superficies of our globe. In this view of the subject, my former account of the sea purging itself upon the land, by the motion and force of the tides, receives new light and strength.

I cannot be brought to believe that the tides
would

would move round gradually and smoothly; but that when any given parallel of the globe was so far advanced eastward during the height of the tide, the moon's attraction would fail to act where the tide was at the height, and would act in its greatest force further west, which would cause the tide to rush from that height after the powers of attraction. Our trifling tides now do not move with such smooth uniformity.

Let us state the case, that the powerful attraction of the sun and moon upon the fluid surface of the terraqueous globe, would raise the tides to the height supposed, and that the highest part of the highest tides really was upon those two parts of the globe which are now the two continents, when the earth would be moved a considerable way eastward, during the height of these tides, and the moon's attraction acted much further west, these tides being forsaken by the powers which raised them to that height in those places, would soon begin to yield, and by their own weight, aided by the powers of attraction, at their greatest force they would rush forward with a force and motion so violent, as quite to overbalance the powers of attraction for some space of time, as I hinted above; and perhaps the effects of that quick motion, or run of the tide, would not finally cease or fail, untill it had gained the opposite side of the globe, a little past the main point of attraction, so that it would always,
during

during that state of the chaos, be high water upon the same two opposite quarters of the globe, once in every twelve hours, and a little more; and that it required the intermediate space of time for the tide to run westward from the one continent to the other, and of consequence, that the mean height of the tides would be upon those two quarters of the globe which are now the two oceans. But I suppose that the tides would run through the spaces which are the two oceans, without any stop, real or partial, rest at a height, and that they would only rest at the height upon the two continents.

If it is allowed that the two continents were the quarters of the globe where it always was high water, at the end of a little more than every twelve hours, it of consequence must be allowed that the tides ran without stopping through the two oceans in the intermediate space of time.

When the tides in the chaotic state of the earth once attained their highest pitch upon the two continents, as I observed before, they would stand still without rising or falling any thing material for some space of time, and that always at high water; during which suspension of the tides, the earthy matter would subside plentifully upon those two quarters of the globe; and if, as I have supposed, the tides continued to run all the while in the two oceans, during the high water

in those two quarters, the earthy matter being carried forward by the waters there with a rapid motion, could not subside so plentifully in the oceans as upon the continents, where the waters came to a stand for some short time at the height of each tide. Of consequence, there would soon be a greater depth of water in the oceans for the powers of attraction to act upon, and these waters would be powerfully drawn over the continents by the force of these high tides ; but the powers of attraction could not have the like effect upon the continents, to draw such high tides into the oceans. In this view of the subject, it appears, that the earthy matter would subside and be spread out by the motions of the tides, in such quantities upon the two continents, that it would be so much exhausted upon the land, that there would not be a sufficiency left mixed with the waters to raise the bed of the ocean as high as the land, when the height and force of the tides began to abate, upon the emerging of the firm land, and contracting the fluid superficies into less room.

If this history of the tides is allowed to be true, (and I do not see how it can be doubted), it throws much light upon my method of accounting for the phenomena of nature, and makes my history of the formation of the superficies of the earth, and of the mountains, plain and clear to a demonstration.

When

When the tides at first were highest in those two quarters of the globe which are now the two continents, they would of course be always lowest at the same time in the ocean ; and as I observed, there would be no suspension of the quick run of the tides in the ocean, except when it was low water there ; consequently, though strata might be formed in the run of the tides, especially when weakest, yet there could be no subsidence properly speaking in the bed of the ocean, but only at the lowest pitch of the ebb tide.

When the tides rose very high, they of course fell proportionally low ; and of consequence, the same process of strata, &c. would be formed upon the solid superficies of the globe for some depth under the ocean, as upon the dry land.

I shewed before, that the strata and unstratified rocks were formed by water, in different degrees of motion and rest, or in other words, by the tides running, and at the height ; and if the tides were always highest upon the two continents, it is easy to conceive how the land happens to be so much higher than the bed of the ocean. If the tides rose in the chaotic state of the earth to the height supposed by Mr Fergusson, it is easy to account for the great height of the highest mountains, as the tides then rose much higher than the highest of them.

When this planet was in the chaotic state supposed, the tides would rise in a line from north to south, or thereby, and these tides would be highest at the equatorial parts, and they would diminish in height gradually, as the line receded from the equator towards the poles. It is natural to suppose, that as the tides were highest in the equatorial parts of the globe, agreeable to Mr Fergusson's scheme, so would they run foremost there, and the line of the tide would recede a little backwards towards the east, upon both sides of the equator. This bending back of the line in the run of the tides, is a necessary consequence of the height and situation of the equatorial parts, the powers of attraction being greatest between the tropicks, and diminishing gradually towards the poles. Upon this supposition of the line of the tides, the course or bearing of the strata in the equatorial parts of the globe should be true north and south; and as the strata advance from the equator towards the poles, this line should lean back towards the east on both sides. It is said that they trend north and south at the equator, and I am confident it must be so. In our latitudes, the line of bearing of the strata is as true to this supposed line of the tide as can be imagined, which is nearly north-east, or between that and N. N. E.

If

If the tides were then highest at the equatorial parts, the highest mountains should be there also, and accordingly it is there we find them.

Our mountains in these northern regions are but diminutive, in comparison to the Cordilleras in South America, and others between the tropicks; and if the greatest, middling and lowest height of all the principal mountains in the world, and the latitudes they are found in, were examined and compared with this scheme of the tides, we shall find them correspond with it as near as could be desired or expected. Indeed, we shall find a beautiful agreement and correspondence in all the phænomena of nature, if we will but take the trouble to investigate them a-right upon the principles of nature and truth.

In the chaotic state of the earth, the deeper the fluid then was, the higher the tides would rise, as the fluid mass would be affected to the bottom by the principles of attraction, which is a sufficient reason for the tides rising so high in that state of the globe, before the solid strata upon the surface of it were formed, and the same holds still in some degree. The tides now affect or move the ocean to its greatest depths. This must happen in consequence of the nature of attraction. If a fluid is moved at all by virtue of a distant body acting upon it by attraction, it must be moved to the bottom of that fluid; and therefore,

therefore, our ocean is still moved to the bottom by the tides, which is the reason of its purging itself on to the shores of all bodies thrown or carried into it, excepting masses of metal, or others too ponderous for the waters to lift or move from the bottom.

It is certain that all the phænomena of nature correspond with, and mutually explain one another, if we can but investigate them upon the true principles of nature. The flux of the tide towards the land is to this hour stronger and more rapid than the reflux, and this stronger and more powerful flux of the tides, still continues to bring back to the shores such matter as is carried into it by the rivers, &c.

As the tides must necessarily have been highest between the tropicks, it follows, of course, that the flux and reflux must also have run with greater violence there in the chaotic state, than in the remote north and south latitudes; and this more violent motion of the tides in the equatorial parts, would occasion deeper terrestrial and submarine runs than in remoter climates; and this also is proved in fact, by the prodigious gulphs and immensity of islands and rapid currents found between the tropicks, and near them on both sides.

I hope I have now removed all difficulties out of the way, for accounting for the great height
of

of many of our mountains, above the level of the sea, and of the champain countries. The highest tides would first lodge the granite mountains as a foundation, and future tides not quite so high would form the strata, which in some places we find riding above the highest granite rocks, and in others running parallel with them.

It is proper to observe here, that it appears to me more than probable, that many of the great ranges and clusters of mountains were formed at first in a great plain above, and were afterwards cut through and furrowed, which I will explain in my next general head of this history of mountains. There is one very material circumstance which I have frequently observed, which greatly strengthens this opinion, and it is this. I hinted before, that I have traced the same range of strata through several hollows, and over several mountains in the Highlands, in the course of which investigation, I have frequently traced the same individual stratum, and a number of strata from the deepest gulph or hollow, up to the summit of the mountains on both sides of the hollow; and where a river cut right across the strata, I could see perhaps several hundreds of them ascending gradually on both sides, with an easy acclivity from the bottom quite up to the tops of the hills; and this plain phænomenon is found
all

all over the Highlands, where the rocks are bare, or much cut and traversed by rivulets.

The extensive countries of Abyssinia, Tartary, and New Granada, are all of them a great height above the level of the sea, which appears to me as instances of such high land; but not cut through to make mountains of.

Where we find an extensive elevated plain in any part of the world, such as New Grenada, and Abyssinia, we may suppose that the tides fell so low, as not to overflow these plains soon after they were formed, by which means they have not been cut through and furrowed like the mountains, by forcible tides frequently running over them; whereas, on the contrary, where we see ranges of mountains dreadfully ploughed and trenched, with deep glens, and horrible gulphs and excavations, it is certain that weighty and powerful tides have repeatedly run over them for a considerable space of time, and perhaps those tides were raised to seven-fold rage and fury by mighty storms, which tides would tear up the humid tender strata; and by repeated mighty runs, would trench and wear down the gulphs and excavations of the mountains, before the induration of the strata had sufficiently taken place.

III. I will now proceed to examine and explain the external phenomena of the mountains, and of their glens and excavations.

I have clearly proved and illustrated one important point towards understanding and explaining such phenomena of nature as appear upon the external surface of the globe, viz. that in the chaotic state of the earth, the tides rose to a surprising height, and if the tides rose to that height, I need not suppose, (the proposition has its foundation and proof in the nature of things,) that the earthy matter sustained in, and agitated by such amazing tides, would be lodged with unequal superficies. This must necessarily happen. Such high tides must be greatly agitated from their own weight, and the violence of their motion, with sometimes the addition of strong winds, and consequently stony matter carried by water in such a degree of agitation, must be lodged in unequal cumulations.

I must not here be understood to mean that the mountains were lodged by the tides at first, as they now appear. I will presently make it evident, that they owe many of their present phenomena to some future operations—I might call it future depredations. What I mean at present is this, that the tides, while in full height, in their motion from east to west, lodged the stony matter upon what began to be the solid superficies of the globe, in parcels or cumulations of different degrees of height and extent; but these higher cumulations, or parcels of land, would be of ve-

ry

ry different degrees of extent; some of them might not be so much as four or five miles over any way; and some of them again would be much more than four or five hundred miles in some directions.

These higher parts of the earth, when first formed, would be comparatively, but not perfectly, of equal height above, and they would be afterwards cut and furrowed, which will be explained.

That the superficies of the globe would at first be formed with higher and lower places, or regions, is so evident, that I need not use more words about it; and it is evident that when the strata and rocks were formed by subsidence and the motion of the tides, the superficies of the earth would at first be soft and humid, and mixt with a great quantity of water, as I observed before. As the tides rose at first much higher than the highest mountains, such tides would advance with a strength, weight and force, able to carry any quantity of stony matter with it; and when these tides had gained their highest pitch, and came to a partial stand at the height, it appears to me evident, that very great quantities have been lodged by subsidence in some places upon both continents, by a particular tide, even to the height of a considerable mountain.

There

There are mountains of granite in the Highlands of Scotland, and many other parts of the world, of great height and extent, in which there is no vestige that should indicate their having subsided at different times. The whole mountain, as I observed before, being one uniform mass from top to bottom. It appears to me, that the work of forming rocks by subsidence, would be performed in a short time, in the course of a very few tides; but on the contrary, that the stratification of the superficies of the globe was a more leisurely operation, which would require much longer time, and a great many succeeding tides. Moreover, the stony matter of which the granite and other subsided rocks are composed, is such, that if ever the tide ceased in the least from the full force and rapidity of its forward motion, we would expect that a great quantity of it should subside at once, as this rock is composed of large grains of a ponderous quality, some of which are so large, that they may be called fragments; and it is the property of such ponderous grains and fragments, to subside suddenly in water, at any degree of rest.

When the tides rose so very high, they would of consequence fall proportionally very low, so that we may say that the foundations of the mountains would be seen; and when the waters, at the ebbing of every tide, began to fall away from the

summits and sides of the mountains and higher grounds, the moisture which remained mixed with the newly subsided or stratified matter, would ooze, or strain out, copiously at first, and this water filtering and straining out of the humid superficies, would soon collect into small streams, and these streamlets would wear furrows in the yet soft and humid surface, especially when assisted by the weight and force of succeeding tides.

Many of these small streams would collect and form a rivulet, and many rivulets uniting their currents, would become a river. It is easy to conceive that all these streams, especially when collected into rivulets, would at first wear their several channels very fast, and that much of the newly subsided matter would be carried down the several rivers, most of which would be lodged far down, and this would be removed by future tides, and disposed of in strata.

I can find nothing in nature sufficiently suitable to illustrate this subject by ; only I may observe in general, that any trifling subsidences which we have occasion to see after great inundations in rivers, and after the tides in slimy creeks and bays of the sea, generally fall into uneven superficies, especially when the waters are greatly agitated ; and as the waters of the floods and of the tides fall away from such sediment, we always see

it

it furrowed with gutters, by the straining out of the water at first contained in it.

I have seen between some tides at the sea side, deep gutters worn by the water filtering out of the mud and sand, and the higher and larger the heaps were accumulated, always the deeper the gutters; and it is probable in the highest degree, on an accurate survey, we shall find this observation hold good in the great as well as in little. The higher the mountains, generally, the deeper the glens and gullies in proportion.

I observed before, that the lesser streams and rivulets collecting together composed rivers. These rivers would still follow the great waters of the ocean in the retreat of the tides, and the weight and force of the rivers would soon wear channels deep enough to contain them, as they advanced after the great waters down the hills and through the planes. This appears to me the true origin of rivers, and the rains which fall upon the earth from time to time, and in greater quantity upon the higher than upon the lower grounds, still replenishes their channels with never-failing supplies, and enables them chearily to continue their courses, and communicate sap and verdure to the vegetable tribes of the valleys, and plenty, pleasure and refreshment to the animal world, as they gently advance along in serpentine

pendine meanders through the sweet and beautiful valleys and extensive plains.

There are yet a great number of the external phenomena of the mountains which deserve to be examined and explained. There are among several mountains, a great number of gulphs and chafms, romantic precipices, gashes and irregularities in rocky countries, which are not now the beds of rivers, nor of rivulets, but are perfectly dry; and I have seen the opposite sides of some hills resembling one another so exactly, that they appeared as if they had been cleft asunder by some convulsion which the earth might have suffered. I have met with some, who assert, not only that such hills parted from those upon the opposite side of them, but also, that several known islands were by some violent concussions thrown off from the opposite lands, and that the sounds between them were made by these accidents.

With respect to such gulphs and chafms among rocks and mountains, as mentioned above, although they may now be dry, yet, nevertheless, water has been there. Some mighty current, rush, or eddy of the tide, before the ocean was settled in its present bed, undermined, scooped out, and formed these irregularities at first.

I have given some attention to the supposititious twin sides of mountains, and in very many instances

stances have disproved the supposed breach and separation, having seen the strata washed clean by the rivulet which ran betwixt them, keeping a regular course down the side of one of the hills, across the rivulet, and up the side of the other hill in the same longitudinal line of bearing, and the same slope or declivity perfectly whole and regular, without breach or fracture, which makes it clear to a demonstration, that such hills had suffered no such separation, change, or convulsion; but, on the contrary, that they stood as firm as ever where they were first formed, and that the gulph betwixt them must have been scooped out by some strong current of water, before the induration of the strata was compleated, and the tides fully subsided.

I have carefully examined many such places, and every where found these observations hold good; and I am confident, that the notion of islands falling off from the main is an error, a hasty conclusion of the same kind, and that the same real and natural cause produced both these effects, viz. a strong current or run of water, which cut a passage betwixt the island and the main, and betwixt the two correspondent sides of the mountains: and when we consider, that the same arrangement of strata stretch through both sides of the mountain, and of the valley betwixt them, the phænomenon of the same strata appearing

pearing on both sides is plain and simple, and just as it should be, allowing that water cut the hollow betwixt them ; whereas, if the one had broke off from the other, the strata could not have appeared so fair and regular in stretch and declivity upon both sides ; but the one side must have differed considerably from the other.

All the little examples of revolutions, or violent concussions, which we have occasion to see, such as earthquakes, the undermining of rivers, and of the sea, &c. are so inconsiderable and trifling, that they give no sanction to this rash hypothesis ; and moreover, what falls off or is broken and disturbed in these little instances, is always broke into confused fragments, or crumbled down to an entire rubbish.

It is reasonable to suppose, that in the raw and humid state of the earth, at first, a great quantity of a mixed vapour would ascend by exhalation, which would disturb the elements, and raise strong and violent winds ; these winds would superadd an additional force to the high tides, even after the mountains were formed, which tides, at any rate, were exceeding strong and violent when they rose to such an amazing height ; and the forward course, and the eddies of these tides, would have a mighty effect upon the external surface of the earth, while they rose so high

as to flow, or rush over any part of it before the induration of the strata was far advanced. I make no doubt, but all the great hollows, gulphs, precipices, and other irregularities we so frequently see upon the face of the earth, took their rise from these causes. There is no room left to doubt of it, as all the external phenomena of the superficies of the globe carry evident marks of water upon them. I have observed, I believe, more than once in the course of these enquiries, that there is an exact agreement and correspondence in all the phenomena of nature, by which they are naturally explained and illustrated, if we had but the attention and skill to discover and make proper use of this connexion and agreement. I am going just now to produce a very remarkable instance in point, which will throw light upon the external phenomena of the mountains, and make the explanation of them more plain and perspicuous.

Every observing person must have frequently seen in plains, at a little distance from large and high mountains, a prodigious quantity of coarser and finer gravel, some of it containing large boulders, and water rounded bullets of all sizes, mixt with smaller gravel, differing nothing in appearance from what we often see upon the sea-beach; and some again composed chiefly of smaller gravel. This beachy gravel is often found spread

out

out with a plane superficies, and as often accumulated into long, round, oval, or semi-circular hillocks of lesser or greater height and magnitude, and some of them so large, that they may be called little hills.

I will point out a few of the many places where I have seen this gravel in Scotland.

There is a great quantity of it in the neighbourhoods of Brora and Dornoch in Sutherland, as also, in the neighbourhood of Balnagown, and between Dingwall and Beuly, in Rossshire. All round Inverness, where there are pretty high hills of gravel,—all the way between Inverness and Nairn, and at Fort George.

There are large hills of gravel about Forres in Moray, in which there is a vast quantity of large bullets, and it continues to appear in hillocks, and spread out in planes all the way between Forres and Elgin, and all the way between Elgin and the river Spey at Fochabers.

There is a great quantity of it in the country of Monteith, and in a great many places, and in great quantities, in that long stretch through Perthshire, Angusshire, and the Mearns, all the way between Monteith and Stonehaven. There is also a considerable quantity of it between Moffat and Dumfries, and between Dumfries and Thornhill in Nithsdale. These instances are a sufficient specimen. Every attentive traveller must recollect

lest his having seen this bulky phenomenon in many other places, concerning which, I will make this remark: That in Britain, the greatest quantities of this coarse gravel are found a little to the east of large and extensive mountains; but of all the countries I have yet seen, the most amazing quantities of this gravel is found in the shires of Inverness, Nairn, and Moray, which lie directly to the eastward of the great run, or gulph, which stretches or cuts through the mountains from the west to the eastern coast, by Fortwilliam and Inverness.

It is very evident that this immensity of rounded stones and gravel, is all of it the spoils of the mountains which was torn by the force of water out of the numberless glens and gulphs, and other excavations of the mountains, which I beheld with astonishment and pleasure off the top of Bineves.

It must be owned that there is, at first sight, an air of truth and propriety in what I advance concerning the source and origin of the plains and hills of gravel which we see so frequently. It appears to me plain and evident, that the stony fragments torn by the violence of water off the superficies of the rocks in these mountains, was afterwards carried through the hills, and after being tossed and rolled by the violent force of the water in so long a course, until it was rounded

and worn by water, like what we see upon the sea-beach, it was at last lodged by the water in the countries where we now see it; and the greatness of the quantities found in those countries sufficiently proves the source from whence it came. We may, upon the same principle, account for most of the phenomena we meet with upon the face of the globe. If we have recourse to water, the solution of the phenomena will be natural and easy; but on the contrary, if we refuse its agency, we shall be left in the dark, to doubt and conjecture without end.

How delightful is the path of truth, when we have once found it!—how clear and satisfactory are the plain and unbiaſſed dictates of nature! When I was upon the head of Bineves, and several other mountains in that country, I was as much amazed at the profundity of the hollows, as at the height and multitudes of the hills; and if we consider the prodigious numbers of the greater and lesser glens that are made, the lakes and gulphs that are scooped out, and the runs that are cut through these mountains, from sea to sea, we are obliged to suppose that the quantities torn off the superficies of the strata, was even still more than the beds and hills of gravel can account for. Great and extensive as those are, they do not correspond with the excavations of the mountains; and we are not left to look for it all in the gravel
beds.

beds. We see a much larger deposition of it than the accumulated gravel, where it is much better disposed of.

The beds and hillocks of gravel are a great nuisance. Nothing but dry sterility reigns where they are; and had all the spoils of the mountains been spread upon the plains, the plains and valleys would not, as now, have been the scenes of the wealth and pleasure of man—every low field and valley of them had been all covered with bullets and gravel. But happily for us, the greatest part of this nuisance is disposed of in rock—strata I cannot call it, as the coarse sort, which differs nothing in appearance from the hills of gravel, is not stratified. The only material difference between the one and the other, I mean between the coarser breccia or pudding rocks, and the coarser gravel hills, is, that the rock is stowed out of the way, bears its proportion of the solid bulk of the globe, and is cemented and indurated to a high degree; whereas the gravel beds and banks are a great nuisance, and are generally quite loose, without cement or connection. I say generally—for I have seen some gravel plains half cemented, and very hard to dig for the high roads.

In order to give a further idea of the proportion between the matter scooped out of these mountains, and the repositories where it is lodged,

I will just point out a few of the places where I remember to have seen most of this rock in Scotland.

In this cursory review I will begin with the north.

There are extensive rocks and high cliffs of the breccia or pudding-stone upon the south shore at the west end of the Pentland Frith, to the westward of Thurso in Caithness, which stretch quite across the county of Caithness into Sutherland; and in Sutherland as well as Caithness, this rock is of a rough contexture, and appears in pretty high hills, deep glens, overhanging rocks, and frightful precipices, to the west of Brora, Dunrobin, and Dornoch, which gives it a grotesque and formidable appearance in that country.

This range of breccia stretches also quite through Sutherland, and likewise through Ross-shire, the west side of Ferndonald, and Dingwall, where it exhibits the very same phenomena as in Sutherland and Caithness.

It is worthy of remark, for the information of the curious, that there are remains of several ancient vitrified forts upon several eminences in the line of this range of breccia, which I have seen in Sutherland, Ross, and Inverness-shires, such as one at Creich, name unknown, Knockferril, and Craighadrack.

The

The ruins of two of these vitrified forts, viz. Craighadrack and Knockferril, were described a few years ago in a pamphlet which was published, entitled "Account of remarkable ruins of ancient vitrified forts, lately discovered in the Highlands and north of Scotland." These singular ruins are to be seen in a great many places; but it is remarkable, that they are only to be seen upon rocks and eminences of the breccia.

This formidable range of the pudding rocks still continue the longitudinal line of bearing, which is nearly from north-east to south-west, quite through the highland countries of Inverness and Perth-shires. It forms considerable hills, and very high and rugged rocks upon both sides of that beautiful piece of fresh water, Lochness. Much of the stone here, as well as in other places in this range of rocks, is composed of large bullets; the rock is very hard and strong, and it hangs in frightful precipices upon both sides of the lake, through which rock General Wade cut a fine military road upon the south side of the lake, at a great expence of time, labour, and gun-powder.

I have seen these rocks stretching through the mountains of Stratherig into Badenoch, where it forms a remarkable rock and precipice called Craigdow, or the Black Rock.

I have seen this identical range of rocks again, further towards the south-west, in several places to the south of the Black Mount, and in the country of Glenorchy in Argyllshire: I suppose that the longitudinal line of this rock, so far as I have pointed it out, is little less than two hundred miles, and in some places this rock will spread eight or ten miles in what may be called the latitudinal line across the bearing of the rocks, which evidently points it out to be a very considerable thing.

The next most magnificent range of the breccia which I have yet seen, is situated above sixty miles further east than the one above-mentioned.

The one I am now going to point out emerges out of the sea at Troop-head, upon the south side of the Moray Frith, and stretches through Aberdeen-shire into the Mearns, and through the whole length of the Mearns, Angus and Perth-shires, keeping principally the northwest side of the country of Strathmore, immediately under the south-east side of the Grampian mountains, though sometimes it strides across the beautiful valley of Strathmore, and is found upon the south side of it, as at Kinfauns below Perth, &c.

There

There have been several vitrified forts upon this range of breccia also, some of which are pointed out and described in the pamphlet mentioned above.

This remarkable rock stretches through Perthshire into Stirlingshire, through the country of Monteith into Dunbartonshire. It crosses the river Clyde near Dunbarton, and reaches into the west side of Ayrshire, where it enters the Frith of Clyde, and I can trace it no further. This range of the breccia exhibits in many places the same interior and exterior phenomena as the first described; and in other places in this long stretch, it is found of a finer contexture, and composed of smaller gravel, where we see it regularly stratified. I am not sure that this course of the breccia is not still of greater length and breadth than the first. There are other arrangements of the breccia in many parts of the Highlands and north; but none so considerable and extensive as the two I have pointed out. There is also a considerable quantity of this rock found in the countries of Annandale and Nithdale, particularly in the neighbourhood of Dumfries, between Dumfries and Moffat, and between Dumfries and Thornhill, &c.

The Pudding Rocks found in the Highlands and north of Scotland are so very extensive, that when joined by the hillocks and beds of loose
bullets.

bullets and gravel in those countries, I doubt if the excavations of the Highland mountains to the westward would be sufficient to supply the prodigious quantity requisite for composing these rocks and accumulations of gravel. I am confident, that a considerable part of the composition was carried through the Highlands from the western isles.

When I was upon the summit of Bineves, it appeared to me evident, that the Hebrides or western isles of Scotland, had been at first formed all in one continued stretch of land with the contiguous Highlands, and with one another, and that the diversity of founts, gulphs, and runs, which now separate the isles from one another, and from the neighbouring main land, were afterwards cut through and scooped out by the heavy tides, before induration was completed.

When the formation of the superficies of this globe was so far advanced, and the ocean was so far purged of the stony matter upon the land, as that the tides could not rise so high as to flow or run from east to west over the tops of the highest mountains, and before they were fallen so low as not to overflow the valleys and lowest hills: In this state of the terraqueous globe, the tides would suddenly and impetuously swell the Atlantic ocean in our longitude, as well as in all others, as they advanced from east to west. As
these

these still high and powerful tides could not now advance straight forward over the continents of Asia and Europe, and the range of the Alps, &c. they would advance in the Atlantic ocean into our neighbouring longitudes, with a prodigious head, weight and force, which would swell the ocean to the south and west of this island, &c. to a prodigious height all at once; and these monstrous tides rushing down upon the west coast, would tear up the newly formed land in many places, produce all the founts and runs, &c. between the isles, and then carry the superficies of the strata so torn off forward before them, quite through the runs and low passages in the mountains, and lodge it where we find it to the eastward of these islands, and of the gulphs through the mountains.

The Atlantic ocean falls now with great weight upon these isles, and upon the western coasts of Scotland and Ireland; with what prodigious weight must we suppose it would rush upon them then, before the force and violence of those high tides were much abated! The Pentland Frith, and other divisions of the Orcades, and perhaps I may add the British channel, &c. were cut out at this state of things; and allow me to advance this sudden and powerful swelling of the tides, after the principal part of the solid superficies of the globe was formed, as the efficient cause of

all the islands, gulphs and runs, in all parts of the world. I need not enlarge and descend to particulars in this investigation. The phænomena are so very obvious that they explain themselves.

I see many indications of the islands upon the west and north of Scotland having at first been all one continued land, and joined to the main, and of their being afterwards disjoined from the main and from one another, by the force and weight of future tides. The strata in the western islands of Scotland are remarkably flat and regular. I have seen some of these strata stretching from one island to another, and still preserving the same course and declivity in both, and I have seen the regular strata in some places, stretching from the main land to the islands, and in other places, from the isles to the main land. I observed before, that the position of the strata in the Highlands upon the west coast, are in general very regular and moderately flat, as well as in the western isles, and from many sites in that country, a great number of the isles still appear all as one land with the main; but upon shifting the station, we discover the sounds that part them asunder. The mountains in the isles of Skye and Rum, are rather higher than those upon the main near the coast, and the same may be observed of the island of Jura, and some others;

and

and it is remarkable, that the weighty and rapid tides which cut the islands off from the main, and ploughed the deep channels that divide them from one another, made very great impression upon the west coast of the main land. This observation is evident, from the great number of friths, sinuses, or arms of the sea, which every where cut and indent the west coast, in such a surprising manner, that in many places there is not above two or three miles between them, and the most of them push a great way up into the heart of the Highlands, and many of them appear now like narrow canals sunk deep among the highest of the Highland mountains, and the banks of several of them are frightful precipices and rugged rocks rising to an amazing height above.

It deserves to be noticed, that a considerable river runs into the head of every one of these canals or lochs, as they are called; and I believe it holds every where, that the larger the river, the the longer the salt canal, which suggests the idea, that the first advances of a mighty stream tide entering the channels which these rivers had begun, in the tender and newly formed strata, would easily, by its prodigious weight and force, plough up the bottom of the channel to a great depth; and so make room for succeeding tides to form such channels fit for the salt water lakes, which

which they now contain. And it is very probable, that some lesser or greater streams of water beginning channels in several places, would first give entrance to the tides which cut asunder the isles from one another, and from the main. It is also remarkably to the point in this investigation, that the tides in the period I mention, were very near making a great many more islands upon the west coast of Scotland, as there are many places where only a very small tack or isthmus of land separates the heads of two of these lakes, and prevents them from running into one another, and of forming an island; such, for instance, is the narrow isthmus at West Tarbet in Argyle-shire, not above a mile over, which, nevertheless, prevents the large peninsula of Kintyre from being an island. There are a great many of these narrow necks of land upon the west coast; and it is remarkable, that in all of them that I have seen, a bar of hard rock striking right across the course of the tide from the westward, has stopt its progress before it cut a passage quite through. I am confident, that if the isthmus of Darien, and all the other famous necks of land in the world, were examined in this light, it would be found, that there are in them all some strata or hard bars of rock, stretching right across the course of the tide. I have

no doubt, that this observation will generally, if not universally hold true.

We see such distinct and evident marks of water upon all the phænomena of the superficies of the globe, that it is impossible to deny it without being guilty of the most absurd obstinacy; and it is equally impossible to account for those phenomena, without admitting the agency of water; and if we admit of water in different degrees of motion and rest, then all the phenomena upon and within the superficies of the globe, are easily explained in a clear, decisive, natural and satisfactory manner. If we view the subject in a proper light, the explanation shall be unanswerable and clear to a demonstration.

I have heard it observed, that the mountains of Britain and other countries stretch from east to west, but I suspect that this is only a hasty conclusion from a cursory view, of which there have been but too many upon this subject. We know with certainty, that the longitudinal bearing of the strata is from north to south, or to the west of south, which was the exact line of the tide, and the tide was the efficient cause of the disposition of the strata. We have seen also, that the declivity of the strata in general is towards the east or south-east, and that they rise and crop out towards the north-west, excepting in such low places where there might have been an eddy
of

of the tide, or where it must of necessity have turned in, or backward towards the land, from some neighbouring sea after the tides began to abate. Now, from the disposition of the strata, we ought to find ranges of mountains stretching from north to south, or to the westward of south; and I suppose, if we examine the matter a-right, we shall find it so in Britain. It is much longer from Thurso in Caithness to the Mull of Galloway, than from Aberdeen-shire to the west coast of the Highlands, and the mountains of Galloway are not the last links in the chain from north to south. They reach all the way through Cumberland, &c. to the south side of Wales, with no other interruptions than what have been cut through and widened, by the tides rushing down upon the land from the Atlantic ocean, as I hinted before. It is true, that many single mountains in a chain, appear in ridges from east to west; but it is plain and easily conceived, that these ridges would be formed by the running of the high tides after the strata were deposited.

I have mentioned more than once, that in general the strata dip towards the east, and rise towards the west; and I will now observe, that it is this position of the strata that was the occasion or natural cause of the many abrupts of mountains to the west in this country; and many of these

these abrupt precipices will occur in all countries under like circumstances as with us, and not otherwise.

The expression *natural cause* may require explanation. When the decline of the strata is towards the east, the east side of each stratum dips down beneath other strata, and is thereby defended from external injury. The acclivity of the strata, on the contrary, being towards the west, the west side of each stratum rises and crops out to the day, and is thereby exposed to external injury.

I shewed before that the tides in the Atlantic Ocean, after the highest lands were formed, would rush down with great weight and force upon the west coast of these countries.

Now it is easy to conceive that such tides must undermine and bring down the outer edges or sides of the strata so exposed, both upon the west coast, and as they advanced over the lower lands through the runs mentioned before.

Some of the strata upon the west coast of the Highlands, and in the contiguous isles, appear evidently to have been formed by the tides in their return from the western ocean, as hinted before, after they were fallen so low, that they could not run over the continents of Asia and Europe, but could only swell the ocean to a monstrous height, as they advanced westward.

The

The indications I observed of those strata being formed in this state and course of the tides, is their dipping towards the west, contrary to the general dip at a distance from the coast; and that these strata which have the western declivity, are not of the same quality and texture as most of the mountain rocks, but are many of them more like our grittstones, freestones, and the basalts, which I suppose were among the last that took their form and station in the wise disposition of all the parts of this stupendous fabric.

V. I will now advance to the fifth general head of these enquiries, which is,

To examine the nature, quality, size, and figure of the larger grains and fragments found in the composition of our rocks and strata.

In the prosecution of this branch of my enquiries, I will especially examine such parts or ingredients found in the composition of the rocks and strata, as are most singular and remarkable; and the first I will take notice of is *talc*.

1. Talc is an exceedingly curious and singular fossil body. I think it may be called an extraordinary one, as there is nothing like it, or that may be compared with it in the whole mineral kingdom, excepting the mica, which, indeed, is the

the same thing, as mica is nothing but talc broken small. We have no such thing as whole strata of talc ; nevertheless, we meet with great quantities of it upon the surface of the earth, and in the composition of the strata.

Although we find no rocks nor strata of this singular fossil, yet it is so abundantly diffused every where, that we find it visible to the naked eye, either as talc or mica, in the composition of almost all strata ; and we meet with some fragments of it so large, that they carry evident marks of the most perfect stratification in the particular masses, and of these masses being real fragments broken off from their proper beds or strata.

We meet with many other fragments of various species upon the face of the earth, but we can carry most of them to the rock they belong to, compare them with it, and find them to be the same.

But not so with the talc. This singular fossil stands up for itself, and is broken off from no rock or strata now existing in this world, and yet there are but few, if any rocks, that do not contain less or more of it in their composition, either visible, or in particles too small to be seen by the eye. We frequently meet with it in large fragments, imbedded in several stratified mountain rocks. It is a considerable ingredient in the composition of the granite, and more especially of the

white granite. We find that it is a considerable article in the composition of slate, of several species of schistus, and many other argillaceous strata.

The white and the grey broad bedded mountain limestones contain a considerable quantity of it. We sometimes see it in the basalts, frequently in freestone, and I have seen it in lead ore, and in several other mineral substances: But the most glorious and abundant view that we any where have of the talc, or mica, is in the micaceous mountain rock, where we see it in such profusion, that I am persuaded it constitutes one third of the whole composition of some varieties of that stone, which in a clear day gives the whole rock a bright metallic appearance.

I observed before, that several masses of this curious substance appear stratified, and have evident marks of their being broken off from their proper beds. I have seen these masses and fragments in many parts of the Highlands in great profusion, from the bigness of a bean up to the breadth of a man's hand, which had all the marks of being broken off from real strata, as these fragments were not only flat, and of a finely laminated structure, but they had also square sides and sharp angles, such as they should have, if broken off at natural cutters from the original strata. There is nothing in this world that I
know

know of, that exhibits such a finely laminated structure as masses of talc; and when we view the several plates or lamina, after they are separated, it appears the most transparent and purest substance, excepting the diamond. When this substance is found in such small scales or particles as to be denominated mica, it may then be accounted a part or ingredient in the composition of the stones in which it is found, which partake of its texture, as we plainly perceive in such stones as have a flattish running grain or texture. The scales of mica likewise lie flat in the bed, that is, they lie parallel to the bed of the stone; whereas, on the contrary, the larger fragments of talc we meet with in the several strata and rocks may rather be said to be found in such rocks than to belong to them.

The fragments of talc appear to have no relation to the form and structure of the stone, but rather to be accidentally taken up into the composition, as they lie promiscuously in the stone, without any form or order whatever.

It appears to me highly probable, from the tough flexible quality of the talc, and from the figure of its parts or particles when broken down to mica, resembling the scales of fishes, that the mica is a valuable ingredient in the composition of such strata as are broad bedded, and of a tough cohesive quality, such as slates, flags, &c.

It

It is not at all improbable, that without mica, we should have had no slate nor other stones of a strong cohesive quality, which are exceeding useful and necessary for so many purposes. On the contrary, our hard stones would have been brittle, and would have broken into angular glebes, which would have made them very unfit for bridges, harbours, &c. and we must have wanted slate.

If we look attentively into the composition of stones and other fossils, we shall find it a large field, containing a great many curious particulars, so that perhaps we cannot pass through it so hastily as we at first intended; there being much in it to attract our attention, and very deserving our enquiries, if we desire to be better acquainted with the phenomena of nature. I have already shewed, that the mica is a plenteous and an useful ingredient, in the composition of most of our stones; and I will now add to it,

2. The quartz, as equally plenteous, curious, and useful in the composition of our rocks.

Pure quartz, or feldspat, is perhaps as mysterious a fossil as the talc. It is true, there is a species of coarse quartz rock in the Highlands of Scotland disposed in regular strata; but all those strata are evidently composed of fine grains of the pure quartz broken small, as is evident

by

by beholding the texture of those strata which resemble the sugar loaf. Whereas, some species of the purer quartz, as it is found in the strata, has no visible grain or texture at all, but is pure, pellucid, and uniform throughout each grain, and there is one species of it called feldspat, which exhibits a finely tabulated texture.

I will, in the first place, take a little notice of the tabulated species, of which there does not appear quite so much as of the uniform; and then I will take a view of the other species, which appears to be more widely and generally diffused in the composition of the strata, and over the face of the earth. The greatest quantity of the tabulated quartz, or feldspat, is found in the composition of some of our granite rocks, and upon the face of the earth in granite gravel, in places where that stone has been decomposed.

Our granite rocks are chiefly composed of quartz, shirl, and mica. Some of the white granite seems to contain little else besides quartz, or feldspat, and mica, and to have little or no shirl in the composition. The quartz found in the granite appears either in grains or fragments, and these grains and fragments are of various colours, though chiefly red and white, and the several shades and varieties of these two principal colours.

It

It is when the granites are exposed to weather and decompose, that we can discern what they are chiefly composed of, and in this wasted state of it we see very evidently, that the quartz it contains is in grains and fragments, of various sizes and shapes, as well as of various colours. I have frequently seen grains or masses of feldspar in the decomposition, and in the sections of a mass of granite, so large that they might properly be called fragments.

These fragments are of various sizes, and they are commonly of a eubical, a quadrilateral, or a rhomboidal figure, with sharp angles, and these are commonly seen from the eighth part of an inch, up to two inches and more in length.

These fragments of quartz in granite are all hard and fine, of a pure crystalline quality, and they are evidently of a laminated or a tabulated texture, resembling some of our mineral spars, only that the quartz grains are much finer, and more hard and compact than the tabulated spars.

The grain and texture is not the only thing remarkable of these masses of quartz; their cubic and rhomboidal figures also deserves our notice, and to me they have every appearance of being broken off from some original strata; which strata are no where to be found in this world, and yet the quantity of this species of quartz contained in our granite rocks is immense.

The

The quantity of the other species of quartz, which are found in pure pellucid granules of various sizes and colours, and of no visible grain or texture, but which appear uniform and homogeneous throughout, is still more immense than that which is of a tabulated structure.

I will note here, that the word quartz is only an improper name given by me to multitudes of fine grains of various colours, sizes, and qualities, to save time. A proper history of them would fill a large book. Many of them are real gems, and most of them perfectly fine and pellucid. I observed above, that these grains are of various sizes and colours. I found a most beautiful purple-coloured sand upon the north shore of the Moray Frith, in such quantity as to colour the shore in some places, so as to attract my eye from afar. The grains of it were much larger than common sand. I gathered some of it, and upon examination, every grain of it was found to be pure amethyst. I afterwards discovered where it came from, and saw some of it in the composition of very large stones, upon the banks of the river Allgrade in Ross-shire, a few miles up the river. I then purposed to return and make a further search, to see if larger pieces of so fine a stone could be found among the rocks higher up upon the banks of that river, but I never after had a proper opportunity. There are various
grains

grains of several other colours found in the composition of many rocks, and all of them as fine as the amethystine sand now mentioned ; but it would be too tedious to enter into minute disquisitions of this kind. Therefore, I will take a general view of the most common quartz grains, which are of a white or whitish colour, and these are the principal articles in the composition of the greatest number of our rocks and strata.

The granite rocks are chiefly composed of grains of quartz of various sizes and colours. The sandstones and gritstones are evidently a composition, and grains of quartz are as evidently the prevailing article in the compound. With the gritstones may be ranked some of the coarser grained mill-stone grits, and part of the finer breccia, as being composed of much the same materials ; the principal part of which is fine, pellucid, water-rounded stones of various sizes and colours, for each of these grains is a real, distinct, and a perfect stone. The roughest and sharpest mill-stone grits frequently contain garnets, and many large pellucid granules of other equally fine stones of different colours. All the sandstones, and others, which contain larger or smaller grains of quartz, are to me equally as mysterious as the talc. There are no strata in the world from which these several coloured grains could be broken

ken off, and with which they may be now compared and referred to as their origin. The granite rocks are immense. The quantity of rough gritstones, containing pretty large, fine, and hard pellucid granules of various colours, is very considerable; and the sandstones, white, red, and grey, is also immense. Add to these the basalts, and all other rocks containing hard grains of quartz matter, with the loose sands in the Deserts of Arabia, of Barca, and all the other great sands in the world, of which we have small samples in miniature at home, especially in the north of Scotland. Now, when we throw all these together, what a prodigious bulk will it swell to! It is still of much greater magnitude than the mica, though we find this too as widely diffused. The grains of sand have long ago been examined by the curious, and they are all found to be fine, hard, pellucid stones, having their asperities and sharp angles worn off by attrition against one another in water.

I now proceed,

3. To examine the shirl, which is another curious ingredient in the composition of many of our rocks and strata. This remarkable fossil is called *schorl* by the Germans, who give names to all these things. Our British naturalists call it

VOL. II.

Z

shirl;

shirl; and I think it is called *cockle* by English miners; or rather, cockle is the name they give to basalts and other stones in which grains of shirl prevail. Shirl is a hard and heavy substance, of a shining jet black, and of a glassy appearance when found in large grains. The larger grains of it appear to be of a finely tabulated texture, the plates or laminae of which are very thin and fine, but adhering close together, so as not to be of a loose foliated structure like talc.

This curious fossil is found generally in a dispersed state, in grains of different sizes in the composition of most of the granites, in all the basalts, and many other rocks, especially such as are of a granulated texture, and of a black or dark grey colour. Although this stony substance is hard and heavy, yet I am persuaded that it is more fragile than the quartz; and my greatest reason for alledging its greater frangibility is this, that I have not seen so many large grains or fragments of it as of the quartz. The largest grains of shirl that I have seen, did not exceed half an inch over any way; whereas I have frequently seen fragments of the tabulated quartz or feldtspat above two inches the longest way of the mass. I have seen in several parts of the Highlands, a species of granite more black than common, much weathered, and in a state of decomposition; and in the debris of the disunited mass, I could sometimes

times discern that more than one half of it was shirl, and the remainder was mostly quartz.

This was the most perfect view of the shirl that ever I got; and in this debris, or granite gravel, I have seldom seen many grains of shirl up to half an inch over any part of the mass, the most of the largest grains being a little more than a quarter of an inch.

Now, the shirl deserves our attention as well as the quartz and mica. We have no strata of the one more than of the other in this world, and yet the shirl, as well as these, has evident marks of being remains of the ruins of some ancient original strata, of which there are none now to be found, and if there were, it might be a very proper question, How came those strata to be broken to pieces, and the fragments of them to be diffused so widely as we find them in a dispersed state in the composition of our prevailing strata? That the most of our rocks and strata are composed of grains and particles of various qualities and colours, is obvious to the slightest observer. We can hardly cast an eye upon one of our common building-stones, without seeing this observation verified. A due investigation of the principal component parts of our prevailing strata requires more attention. I have bestowed some time and attention upon this matter, and I hope my labour has not been altogether in vain. I have noted a
great

shirl; and I think it is called *cockle* by English miners; or rather, cockle is the name they give to basalts and other stones in which grains of shirl prevail. Shirl is a hard and heavy substance, of a shining jet black, and of a glassy appearance when found in large grains. The larger grains of it appear to be of a finely tabulated texture, the plates or laminæ of which are very thin and fine, but adhering close together, so as not to be of a loose foliated structure like talc.

This curious fossil is found generally in a dispersed state, in grains of different sizes in the composition of most of the granites, in all the basalts, and many other rocks, especially such as are of a granulated texture, and of a black or dark grey colour. Although this stony substance is hard and heavy, yet I am persuaded that it is more fragile than the quartz; and my greatest reason for alledging its greater frangibility is this, that I have not seen so many large grains or fragments of it as of the quartz. The largest grains of shirl that I have seen, did not exceed half an inch over any way; whereas I have frequently seen fragments of the tabulated quartz or feldtspat above two inches the longest way of the mass. I have seen in several parts of the Highlands, a species of granite more black than common, much weathered, and in a state of decomposition; and in the debris of the disunited mass, I could sometimes

times discern that more than one half of it was shirl, and the remainder was mostly quartz.

This was the most perfect view of the shirl that ever I got; and in this debris, or granite gravel, I have seldom seen many grains of shirl up to half an inch over any part of the mass, the most of the largest grains being a little more than a quarter of an inch.

Now, the shirl deserves our attention as well as the quartz and mica. We have no strata of the one more than of the other in this world, and yet the shirl, as well as these, has evident marks of being remains of the ruins of some ancient original strata, of which there are none now to be found, and if there were, it might be a very proper question, How came those strata to be broken to pieces, and the fragments of them to be diffused so widely as we find them in a dispersed state in the composition of our prevailing strata? That the most of our rocks and strata are composed of grains and particles of various qualities and colours, is obvious to the slightest observer. We can hardly cast an eye upon one of our common building-stones, without seeing this observation verified. A due investigation of the principal component parts of our prevailing strata requires more attention. I have bestowed some time and attention upon this matter, and I hope my labour has not been altogether in vain. I have noted a
great

great number of facts, and I hope that I have placed several articles in a clearer light than they were before, and think that I have made several observations which are new, and which will contribute some little assistance to the study and investigation of this great branch of natural history. I have made it evident to a demonstration, that all the rocks and strata which compose the superficies of our globe have been deposited and formed by water in motion, and at rest,—that there are upon the superficies of our globe many obvious marks of there having been very high tides at some period of time or other, which subject I will resume and consider more fully afterwards, when I have done with my cursory view of the larger grains which we behold in the composition of our rocks, such as the mica, quartz, and shirl, and found upon due examination, that although they are the principal parts in the composition of those rocks, they, notwithstanding, did not originally belong to them. In the course of my inspection and enquiries into these matters, I perceive that these remarkable ingredients in the composition of our rocks are inconceivably finer than the rocks which they compose. They have a form and texture of their own, distinct from the form and texture of the rocks in which they are found; and there are no rocks in this world of the same quality and characters as these grains. Our rocks
are

are evidently composed of various different grains and particles of divers colours, qualities, and figures; whereas, on the contrary, these grains have no visible particles,—there is no appearance of a composition, but a perfect homogeneity is found in all of them. There is indeed some little resemblance between the form and structure of some of the largest masses of these, and the finest of our laminated strata.

The talc and tabulated feldtspat are evidently stratified as well as our slates, coal metals, and others, but there is a thousand times more disparity between the fabrication of their several textures, than there is between the coarsest hair-cloth and the finest silk, or cambric. The similitude between them is just sufficient to shew us that water was the agent in the formation of both. There is a homogeneity, a beauty, an uniformity, a fineness in the essential corpuscles and textures of these several fossil substances, which suggests to us that these are fragments and remains of strata, which were created by the Almighty in the first formation of all things. There is an originality and purity in these, which shews them to be as they came from the hands of God at first, when he created all things out of nothing. They are infinitely finer than our coarse compounded strata. At the same time, I am confident that they would not be so well adapted for our several necessities

cessities as our compounded stones. I am fully convinced of the contrary. They are too fine and hard to be worked by us, and too bright and glorious in their colours to be endured by our eyes. The present state and appearance of our strata clearly point out to us that the strata which formed the superficies of the globe at the first creation, have been some how or other broken to pieces; and that the present superficies of our globe is composed of the fragments of the ancient strata. But before I enter fully into this consideration, I will just hint at a few other articles found in the composition of our strata, in order to place them in a proper point of view.

Remains of the testaceous tribes, of coral, and other marine productions, have long ago been advanced as proofs of an universal deluge, and they are so. At the same time, I am sensible that a very indiscreet and unmechanical use has been made of such proofs, to countenance and support a lame hypothesis. The evidence of our senses, and the most accurate experiments, prove these to be real shells, and real corals, &c. and no *lusus naturæ*; and therefore, although the earth should be covered with water a thousand times over, these various shells, &c. could never enter into the body and composition of the solid rocks and strata, without the whole of the matter composing such strata, shells, coral, and all, being

ing blended with the water in a chaotic state. All the species of shells found out of the strata, are also found in them; and I have seen them in some places exceeding numerous, even up to near one half of the whole matter composing the stone; and moreover, I have seen them in such abundance in a pit upon the sea-shore, sunk a hundred and thirty feet below flood-mark.

Besides the numerous animal and vegetable spoils of the ocean found in the strata, there have also been frequent discoveries made of their containing numerous specimens of almost all the animal and vegetable tribes found upon the face of the earth.

Many weak and fanciful methods have been employed to account for these phenomena, without having recourse to the universal deluge; but I will say in one word, that it is morally impossible to give any account of them, that is not liable to many weighty objections, and that does not infer many absurdities, without having recourse to the deluge, or to the chaotic state of the terraqueous globe, which I hint at, and which is really the same thing.

I have now made a number of observations upon several of the component parts of some of our prevailing rocks and strata. Allow me to collect the most of them into one point of view. I have, *First*, examined the talc and mica. *Second*, the quartz,

quartz; and all the fine large and small grains found in the composition of our rocks and strata; and perhaps I should have included many of our gems and precious stones under the same head. *Third*, The shirl, of which we find pretty large grains and fragments in the composition of our rocks; but we have no rocks of them in this world. *Fourth*, I have hinted, that our rocks and strata contain in their composition, numberless remains of all the land and sea animals and vegetables. I throw these altogether in one promiscuous prodigious heap. The particulars are to be found in books; but my observations concerning the quartz, shirl and mica, are not to be found in any books that I know of. Now, what shall we do with these prodigious masses of materials which I have collected?

If I am allowed to suppose, that the quartz, shirl and mica, with all the samples we find of fine and beautiful grains in the composition and decomposition of our rocks, were once fair and regular strata,—that these beautiful ancient strata were some how or other dislocated, broken to pieces, and mixed with the waters of the ocean,—that the waters of the ocean, or the terraqueous globe, were raised partly by natural and partly by extraordinary causes to monstrous high tides,—that the ruins of the antediluvian strata were taken
up

up in and agitated by these high and powerful tides, until they were mixed with the waters in a chaotic state; and that this chaos was agitated and carried forward from east to west by the force and violence of those monstrous high tides, until, by trituration and grinding against one another, in the amazing force of that motion, the fragments of the ancient strata were broken to pieces, and ground down into the grains and small fragments we behold, which were afterwards formed into our rocks and strata, after the violence of the first monstrous tides began to abate; as I described in the second head of these enquiries. Now, if it is allowed, that this account of the matter is natural and mechanical, then we can dispose of all the materials I have collected to the best of purposes. A ray of light then shines upon this dark and difficult subject, to shew naturalists the right path, and a foundation is laid, and every difficulty removed out of the way of the future study of the mineral kingdom. So that this branch of natural history may, and I am persuaded that it will in time become as easy, as pleasant, and as determinate a study as either of the other kingdoms of nature.

If these conclusions are allowed to be just and true, then the whole horizon is clear before us; and such a ray of light shines upon every part of this hitherto dark and puzzling subject, that we

can easily and naturally account for all the phenomena which we behold upon and within the superficies of our globe. They will all mutually conspire to account for and explain one another. But, on the contrary, if they are rejected, then we are still in the dark,—we can account for nothing naturally, without being exposed to a thousand weighty objections, and without inferring many palpable absurdities.

I know very well that my observations and inferences run counter to the modern philosophy, which is patronized by many great names in the republic of letters,—but as I am used to examine facts, and to take nothing for granted in these matters, I pin my faith to no man's sleeve ; I regard not the opinion of any sect of men, however high their names may stand, unless these opinions be warranted by fact and experience.

The book of nature is open to me as well as to them ; and if they contradict what nature plainly and distinctly points out, I am not bound to believe them, in direct contradiction to the evidence of my senses. Every thing which I behold in the mineral kingdom favours my persuasion of the universal deluge ; and several of the phænomena of nature advance a step further, and make it necessary. Most of the stones and other fossils I take up in my hand are evidently compounded ; and I know not how philosophy will
account

account for a composition, without allowing of component parts; and as most of these component parts are perfect stones, this directly favours my observations. But I have no talent for subtilty of reasoning; and if I had, my observations do not stand in need of it. It leads us into darkness and perplexity, and in improper hands, leads not only to conclusions which are false, but dangerous and hurtful. I will take quite another method. I will muster up a number of facts in support of my argument, which may be examined by all the world; and if they are not obstinate and wedded to former systems, these facts will open their eyes to the truth. And if, on attentive enquiry, these facts lead to truth, and we are enabled to develope the scene of nature, we will rejoice in having found out the right path, and delight in the possession of it.

It was the will and pleasure of Almighty God, (for the punishment of a wicked generation of men, but for the good and emolument of the human race in general), to dissolve the bands of union, and to break to pieces the strata of the antediluvian earth, and to blend and mix the whole fragments of those strata with the ocean, into a second chaos or universal deluge.

I will by and by offer a few general observations, and I will submit a few conjectures, which may throw light upon some parts of this subject.

But,

But, in the first place, I will examine some positive proofs of the deluge ; which proofs make it absolutely necessary, and which can no way be accounted for rationally, without acknowledging that there was an universal deluge ; and therefore, I will proceed, according to my method,

VI. To select some particular strata for examination, and those strata are the coals and coal metals.

Though I have reserved the strata of coal, and its concomitant strata, for the last of my clear and positive proofs of the deluge, yet I do not reckon them the least important and decisive. I rather chuse to advance them to the first rank, and to give them an eminent station, which they deserve, among the unquestionable proofs of that great catastrophe.

Let no man wantonly condemn what I am going to say upon this head, before he reads and examines it, because he thinks it is to contradict and oppose his preconceived notions. Let him first read candidly, and then let him condemn, if he finds that I contradict the phenomena of nature, and that he can give a better account of the matter.

My

My former disquisitions make it evident to a demonstration, that the strata which compose the superficies of our globe were formed by water; and it is evident, that the most part of these strata are compounded of grains and fragments which have an original appearance, a homogeneity of particles, with evident marks of the finest stratification, and of their being fragments of a great variety of different ancient strata. Now, if it be acknowledged, that the superficies of our globe was formed by water, I think it is necessary either to allow of my account of these matters, or to embrace Count Buffon's hypothesis; and I have made it evident to a demonstration, that the real structure of the superficies of our globe is absolutely inconsistent with his hypothesis, which inconsistency or incongruity I have clearly proved above. I am persuaded, from the little I have seen and been able to investigate, that when all the strata, and all the phenomena of the strata, and of the mineral kingdom in general, come to be candidly and seriously examined, they will all of them be found to point out, not a probability only, but even the necessity of acknowledging the universal deluge, and such a deluge as I have suggested.

But I will leave many of these phenomena to be examined by others, and will proceed to take the coal under immediate consideration; and I believe

believe it is out of my power, and out of the power of any other man in the world, to produce a more clear, compleat and decisive proof of the universal deluge than our pit coal; and also, of the wisdom and benevolence of the Supreme Being, in over-ruling the events and operations of nature, and bringing about the good and emolument of man by that extraordinary revolution.

It appears to me evident and past a doubt, that timber was the origin and principal matter of which coal was composed; and if we allow the origin of coal to be timber, it is impossible to give any rational account of the form and situation of the strata of coal, without admitting the doctrine of the deluge to be true. That coal was composed of timber, is in some measure evident to our senses. I have seen the grain and figure of timber so distinctly in the strata of coal, as to be certain that it really had been timber, and that it really was when I saw it, partly imperfect coal, and partly destroyed or spoiled timber; and it was this observation and discovery that first excited me to enquire and search out the true origin of coal. I am not the only person that has seen the appearance of timber in coal. I have, since my first discovery, conversed with several gentlemen who have made the same observation; but, for any thing I know to the contrary, I was the first that ever attempted to
account

account for the phenomenon, by having recourse to the universal deluge.

Let us take a cursory view of the coals already discovered in Britain, in order to give us some idea of the quantity of this very useful mineral fewel.

What a vast number of seams or strata of coal are there between Haddington and Edinburgh!—between Edinburgh and Stirling!—in the shires of Fife and Clackmannan!—in the shires of Lanark, Renfrew, Dumfries, and Ayr, in Scotland!—What an immense number in the shires of Cumberland, Northumberland, Durham, Nottingham, Stafford, Salop, and all the other coal countries in England and Wales!—and yet what is this small island in comparison of the rest of the habitable parts of this globe?—But a speck. Nevertheless, it may justly be called a fortunate island. It is so wholesome and temperate, and so plentifully stored with all necessaries and conveniences for the employment and maintenance of multitudes of people in a social and commercial state, that perhaps no island nor nation under heaven is in every respect so well furnished, and so highly favoured.

Great Britain is a great word in the mouth of a Briton, yet it is but a spot when we compare it with the rest of the world. What a vast quantity of coal may we then suppose to be deposited in
all

all parts of the superficies of the globe! The quantity must be immense. At the same time, it must be allowed that all parts of the globe are not so plentifully stored with this fewel as Britain. There is almost none in Britain itself, to the north of the Ochil Hills. There is, as yet, but little discovered in Ireland, and still less in proportion in many extensive northern regions.— There are extensive tracts of granite, and other rocks not commonly associated with coal, in many parts of the globe, where none is to be expected; but after all these deductions, the quantity to be found all over the globe must be immense.

It may be properly asked, where I am to find timber enough to produce all this coal? This may at first sight appear to some absurd and impossible: However, it does not appear to me in that light; and I hope to give a satisfactory account of the matter to every impartial enquirer before I quit this point of investigation.

I have good reason to believe, (contrary to the opinion of many,) that there was but a small part of the antediluvian earth inhabited; but as I cannot prove those reasons by indisputable facts, I will not insist upon them, but will leave it as a supposition. It was a small part of Asia, and perhaps a very little of Africa, that I suppose to have been inhabited before the flood; and the modern discovery of human bones in the body of the
the

the strata, and blended in the composition of the solid rocks in the country of Dalmatia, and in several of the islands in the Mediterranean Sea to the westward of Asia, in my thoughts, gives no small support to that opinion. Let us reflect, that Dalmatia, and the islands in the neighbourhood of that country, are directly in the run of the high tides, (upon the supposition of the chaotic state of the earth I insist upon at the deluge,) which at least gives the suggestion a greater air of probability. For we may justly suppose that all such substances would be carried somewhat westward by the high tides of such a deluge, before they would settle with other matter, and be lodged in strata. Allow me for once to beg the question, where I cannot avowedly lay claim to it by proving the fact; and let us suppose, that only a considerable part of Asia, and perhaps a very small part of Africa, were inhabited before the deluge; and in that case, by far the greatest part of the earth lay waste, and of consequence, all the uninhabited parts of the earth would be entirely covered with the tallest and most luxuriant growth of timber imaginable; and at least, one half of the inhabited countries would be in the same condition. America is a sufficient proof that the uninhabited and thinly inhabited parts of the antediluvian earth would be so covered with timber.

Let us examine how much tall timber will grow upon a square mile of good soil, when sheltered by tall timber on all hands :—Again, how much will grow upon a thousand square miles, and so on, over the greatest part of the dry land all round the globe ; and in this view of the subject, we shall find that the original sources of the coal correspond with the quantity of it in the world.

I will here beg leave to propose another probable source of coal. I believe I may call it a real one, and that is the antediluvian peat-bog,

I have really seen strata of coal that have all imaginable marks of being composed or formed of that combustible substance. The colour, quality, and form in the stratum, the manner of burning, the ashes, and every thing else relating to these coals, look like peat. I have seen dried black peats nearly as hard. These coals exhibit no perfect and regular form and grain in working, like other coals, but break into misshapen glebes, like peat clods broken by water ; and I certainly know that peat clods are kept together by the fibrous roots, and are not soon dissolved and mixt with water. The roof or upper side of one of these strata of coal is not level or plain like other coals, but very unequal ; and a stratum of clay which is immediately above it, has filled up all the inequalities of the upper side of the

the coal; and when the coal is taken down from it, the clay roof appears with a rough, unequal, imbossed surface.

One of these singular coals is situated at Breich in Linlithgow-shire, in Scotland, the property of Sir William Augustus Cunningham, Bart.

There are other strata of coal of this quality and description in Scotland, but I only point out this one, because I examined it more minutely than any other.

I know very well that several naturalists, of small knowledge in the mineral kingdom, have advanced the peat-bogs as the effects and produce of the stagnations of the universal deluge; and peat-bogs, being sometimes found in low situations, with several feet of earth above the moss, and a quantity of large timber trees lying in the bottom of these peat mosses, they produce as infallible proofs of the deluge. For the timber, say they, is antediluvian, and the clay, or sediment found above some mosses or bogs, was certainly lodged there by the waters of the deluge; and some of these mosses are now discovered in maritime situations, and by the sides of great rivers, where the tide flows; and many of these are found lower than the present high water mark, which they reckon a corroborating proof of the truth of this hypothesis. Now, as these circumstances

stances seem to coincide and depend upon one another, it may not be improper for me to give a brief account of the natural history of mosses, or peat-bogs, in order to obviate and remove such mistakes about them.

All the peat-bogs upon the face of the globe are certainly post-diluvian. Many of them are of recent formation, and countless numbers are now growing and forming more expeditiously than is generally imagined. Decayed and putrefied vegetables is the origin and matter of which all peat-bogs are produced; and decayed and putrefied vegetables may, and do increase and accumulate in several situations, and from sundry causes. With respect to such as are found as low, or as it is said, lower than the present height of the tides, these are most commonly found in flat bays, and by the sides of considerable rivers, and often not far from where these rivers fall into the tide. In some places there is a depth of sediment above these low peat-bogs, and good soil upon the surface, which has been in culture above a thousand years. Some parts of the Carse of Gowrie, and of the Carse of Stirling in Scotland, may be produced as instances of this kind, where moss is found below, and a good depth of soil above the peat-bog. The CarSES of Gowrie and Stirling are low plains, the one upon the north side of the
river

river Tay, and the other mostly upon the south side of the river Forth ; and it is very evident that both of these, as well as many others in the same country, were formerly the bed of the sea. The tide runs up now further than any part of these two Carfes ; and notwithstanding what many have advanced to the contrary, the tide runs up now every where as far as ever it appears to have run, where the channel it runs in is as strait and free, and not obstructed and filled up by adventitious matter carried by water, and lodged in the channel. A narrow and a crooked channel obstructs the free course of the tide ; and of consequence the tide is well spent before it can force its way as far up as it advanced when the channel was clear and much wider, before it was choaked up and obstructed by sand, gravel, or other sediment from the mountains, which has now filled up many bays, and formed extensive parcels of new land, through which there is now only room enough, in a winding channel, for the river to pass which brought it down ; but sometimes is not wide enough for the tide to pass with freedom, as it did before the bay was filled up. I formerly pointed out the source of the deposition which has filled up these bays, and formed these carfes, and other new land, viz. the numberless rivulets and rills washing down the soil off the sides of mountains and higher grounds, and the
superficies

superficies of the sandy and argillaceous strata decomposing and dissolving with the weather, supplies more matter to be washed down from time to time. I shewed before, that land floods carry down considerable quantities of this sediment, and lodge it commonly where water stagnates, and especially about the meeting of the salt and fresh water. A stream-tide and a strong fresh meeting one another, would throw some of this sediment pretty high into places where there was none before, which might happen to be on a peat-bog, as well as upon any other place.

The phenomenon of the bog itself being found so very low, is very simple and easily accounted for. A bank of sand, or other matter thrown up by the motion of the water in a storm, would form a pool of stagnated water behind the bank. This pool or lake being shallow, and having a fat slimy bottom, a rank growth of many vegetables would soon appear, and these vegetables decaying annually, would soon fill up the water, and form a morass, which by degrees would become a peat-bog.

Trees might grow so near these bogs, as to be in time surrounded by their increase, which trees might afterwards be blown down by the winds, and covered by the growth and increase of the bogs, which in many places is much more hasty than most people imagine. Or, the trees might
be

be there before any such stagnation of the water happened, and their being blown down might begin a partial stagnation, and produce a luxuriant growth of aquatic plants, which would lay the foundation of the bog. When a depth of peat-bog was produced by these or similar causes, a high tide, and a great land flood, with a storm of wind, meeting and acting with united force, would break over the mound which separated the bog from the waters of the river and tide; and when the barrier which was interposed between them was demolished, or a breach made in it, the flood would lay a depth of sand or mud above the bog, and future floods would increase it. These bogs being found now as low as the tide, and the tide still flowing further up in such places, are clear proofs that the sea is not retreating from our coasts, as many assert.

The rivers carry down the spoils of the mountains into the valleys, and the borders of the sea; and the sea purges itself by the tides, and throws it out again into the bays; and at the influx of the rivers, which really pushes back the sea a little from the shores, and lengthens the course of the rivers. The sea in such places appears to many to be retreating from our shores, but it is not an inch lower upon the horizontal level. It is the shores that are enlarging in such places, and new land increasing with the sediment deposited by the rivers,

rivers. The rivers Forth and Tay, in Scotland, have carried down so much sediment as to produce the Carfes of Gowrie and Stirling ; but what are these rivers when compared with the mighty floods which derive their sources from prodigious chains of mountains, and water great continents in their long and weighty course !

The effects will be in proportion to the size of such rivers, and the length of country which they traverse. I shewed before that the effects of the deposition of the rivers is very beneficial to society ; and that many of the fat valleys where some of the most wealthy commercial cities in the world now flourish, were formed by this sediment.

It was hinted above, that decayed and putrefied vegetables is the origin of peat-bog ; and that decayed and putrefying vegetables may increase and accumulate in various situations, and from sundry natural causes.

The falling of trees, and even the falling of the branches and leaves of trees upon humid ground, may begin a stagnation of more water ; and whatever begins a stagnation, lays the foundation of a rank growth and putrefaction of vegetables, which is laying the foundation of a future peat-bog.

Great numbers of lakes and marshes are now making quick advances to become peat-bogs, by the annual putrefaction of a rank growth of vegetables,

tables, and many present peat-bogs were formerly lakes and marshes. There is a beginning of turf or peat-bog in all old fir and pine-woods, among the roots of the trees ; and where much fir timber is found in the bottom of a peat-bog, there is no room to doubt that the bog was formerly the site of a fir-wood, and that the trees were blown down by violent gusts of wind, and the trees being blown down would encrease the stagnation and growth ; and of course, the fallen trees would be soon covered with peat-bog. Any other trees falling, or the leaves and branches of any other species of timber beginning a stagnation of water, would lay the foundation of a peat-bog ; and whatever remains of the animal or vegetable-kingdoms happened to be upon the spot when the moss began, might be found there two or three thousand years afterwards, as peat-bog is known to be a great preserver of many different bodies. There is now an annual encrease of such bogs, by the decay of various kinds of vegetables, where they are neither washed away by streams of water, nor blown away by the winds ;—but of all the feeders of peat-bog, the most common and the most plenteous is heath, and heath is found plentifully in all cold countries, and especially upon poor, sandy, gravelly, and boggy soils. I have seen many peat-bogs with heath growing upon them, the surface of

which consisted of a foot and a half or more of the branches, blossoms, and seeds of the heath, apparently not in the least decayed.

The second stratum down consisted of the same matter beginning to decay a little. The third course produced bad, light, imperfect peat, called flow-moss in Scotland. The fourth, and so on, still better and better peat, the farther down; until it became, at a sufficient depth, perfectly black, and of a close texture, being well digested peat-bog.

This is a sufficient description of Moss-Flanders above Stirling,—of the moss of Kintraw in Ardnamurchan,—of the Solway moss, and of almost all the mosses in the Highlands of Scotland. The fibres, blossoms, and seeds of the heath which fall off, is a copious annual supply; and the depth of moss produced by these supplies is very great in many places which I have seen. In this instance, the cause and the effect tally exactly. But to leave this digression:—The other coal metals, or the strata which accompany coal, are as clear a proof of the universal deluge as the coal itself, or nearly so. Many of these have a small quantity of the coal between their folds and lamina, and in small nests within the solid parts of the strata, and these concomitants of the coal are all as regularly stratified as any other class or assemblage of strata whatsoever. There is one among

among these besides the coal, which deserves particular notice, and that is the ironstone. The ironstones of the coal-fields are disposed in regular strata, and there are in some coal fields a great number of strata of ironstone. These strata of ironstone are generally thin, few of them being a foot thick, and some of them not above an inch. The medium thickness of the bands or strata of ironstone in the coal metals, are from two to five or six inches; but notwithstanding their being so thin, they are nevertheless as regular strata as the coals themselves, and spread as far every way as any of their concomitant strata.

Now, every intelligent unprejudiced naturalist, who has taken any notice of the order and disposition of the several strata in a coal field, must acknowledge with me, that those several strata were spread out, and formed in the order we find them, by successive tides, or by similar streams of water, bringing the matter and depositing it in regular strata. The order in which they are placed, stratum super stratum, promiscuously, in respect to the laws of gravitation; the heavy, the light, and those of medium ponderosity, being all blended together, without the least regard to gravitation, makes it evident to a demonstration, that they were deposited in the order we find them by successive streams of water. Any other way
of

of accounting for this deposition, must be unmechanical and imperfect, and will not agree with the phenomena of nature. The bands of ironstone in the coal fields are commonly found in those black and grey argillaceous strata called till or blaes, which generally accompany coal; and we frequently find two or three, or more, thin strata of ironstone in one thick stratum of blaes, which is the name given by Scots colliers to these argillaceous coal-tills. But it should be observed, that all the ironstone of the coal-fields is not stratified, nor found regular and continuous in the manner of any regular strata. We often find and work ironstone in nodules, balls, and glebes, which are deposited promiscuously without any regular order, in pretty thick and generally soft strata of the coal-till or blaes. This ball ironstone is very commonly found in soft argillaceous strata, of various colours besides the black, as whitish, ash-coloured, and various shades of grey.

These glebes and balls of iron are found in this manner blended in the argillaceous strata, of all sizes, from the bigness of walnuts, up to masses of a hundred pounds weight. The balls are found in less or greater quantities in different strata of blaes; and frequently in less and greater quantities in different parts of the same stratum.

This

This ball ironstone is always of the same quality as the regular strata of ironstone found in the same coal-fields; and the balls and glebes always appear water-rounded, being either found in smooth roundish balls of various sizes, or else in flattish glebes with obtuse angles or smooth rounded edges. Now the situation, order and figure of this ball ironstone, is another proof of successive tides in the formation of the strata. This glebous ironstone was first of all formed in regular strata of various degrees of thickness; but before induration was completed, a stream tide, accompanied by a strong wind, has plowed up and torn off part of the superficies of the strata of ironstone and others already formed; the fragments of which strata, when torn off, were easily rounded by rolling and attrition in the water, before they were perfectly indurated; and these fragments were afterwards deposited by succeeding tides in the soft argillaceous strata already mentioned; which strata of coal-tills, holding glebes of ironstone, and such other strata as are found above them, must have been formed later than the regular strata of ironstone from whence these glebes were torn off. That they were torn off from the superficies of regular strata, is evident, from the glebes and balls being of the same colour, quality and texture as the strata, even to the nicest exactness when compared, and from
the

the thickness of the glebous masses corresponding with the thickness of the strata; and in some beds of till, the glebes of iron have evident marks of the strata from which they were broken remaining.

The richest and purest ironstone of the coal-fields is generally of a fine texture, commonly rising in small angular masses from the stratum, fragile, and easily broke into small angular masses of different figures; and we find the purest and richest ball iron in exceeding small masses, imbedded in the strata of coal-till, of various colours. On the contrary, strata of inferior quality have a coarse grain and texture, are more strong and cohesive, and rise in larger glebes in working it from the stratum. Some of the inferior kinds, when the strata of ironstone are not above three or four inches thick, rise in broad flat cakes or glebes; and I have frequently seen them in as broad and flat masses lodged in the coal-tills, with only the edges or sharp angles a little worn off. Such glebes of ironstone as have been broken off from thinner and thicker strata, still retain evident marks and characters of their stratified state, as the various masses and fragments clearly discover the bed of the stone, having only the asperities and sharp angles worn off. I have endeavoured to explain this phenomenon with some degree of perspicuity and precision; because

because I think it deserves attention, being a clear and convincing proof of the formation of the strata, by successive tides or streams of water in motion.

I observed before, that the various strata found in coal fields, are as finely stratified, as regularly spread out, and as equally thick in continuation, as any class or assemblage of strata whatever; and I will now observe, that the coal itself is likewise as fairly stratified, and as regular as any of its concomitant strata. Many beds of coal are so finely stratified, that they really are of a laminated structure, the plates or different lamina being thin and splitting regularly in leaves of equal thickness, the whole breadth of the largest masses; and I have frequently seen several seams or beds of distinct kinds or denominations, and of different qualities of coal, lying regularly, stratum super stratum, in one individual thick bed of coal, such as splint coal, or stone coal, parrot, or cannel coal, cherry coal, and various mixtures of the rock coals of different and distinct grains and textures, all of them regularly disposed one above another in the same individual stratum of coal, below ground, without any stone or till, or other heterogeneous matter interposed between them. Now, this is a clear proof of the agency of water in a gently flowing motion. If these northern regions were not inhabited, they would soon be overgrown

overgrown with wood, and especially with pines, or fir wood. Tar is extracted from fir wood; and it is remarkable, that of late years it has been discovered that a species of tar can be extracted from coal, which is procured in great abundance by a sort of distillation. I cannot help thinking that this known fact is a good collateral proof of the antediluvian timber being the origin of coal. This mineral tar has a fetid, disagreeable smell, which, no doubt, is caused by its being combined with vitriolic and other heterogeneous particles.

The coal from which this tar is extracted being in a mineralized state, and mixed with various heterogeneous matters, we cannot expect this pitchy extract to be as simple and pure as the resins of timber, but they are really of the same quality.

I am really concerned for the honour of the coal. It is an interesting subject, especially in Britain; and as very little to the purpose has been said about it hitherto, that I know of, I reckon the subject my own, and therefore I wish to be its faithful historian. I have endeavoured to be as clear and distinct as possible in explaining its principal phenomena in a former volume; and I hope that I will be understood. Nothing can make me believe, nor even suspect, that such a wonderful natural production as coal, of such characters and properties, could happen by chance.

Let

Let us suppose that all the particles of matter of which coal is composed to be really existing ; and let us suppose them to be thrown, or any how carried into the ocean, according to the wish of the modern philosophy ; if these particles are left there to chance, when blended with the particles of an infinitely greater quantity of matter entirely of a different quality, (which matter we find disposed in different strata along with the coal,) the known laws of gravitation would render all these combustible particles entirely useless to us. According to those laws, the stony and metallic particles would either be found mixed and compounded with the coal, or rather, they would all sink down under it, in the order of their specific gravities. In either case we should have no coal.

I think that I made it sufficiently evident before, that neither coal, nor any other regular strata could possibly be formed by subsidence in water, that is, by the particles of matter subsiding to the bottom of the ocean, without a miracle. That I may illustrate this matter as much as possible, I will further observe, that we have occasion to see many natural and artificial operations, which clearly evince the truth of what I assert. A recital of one of these may help to throw light upon this part of our subject, and to convince the candid that the coals certainly could not be formed under the sea.

We know by experience that when grains or particles of different degrees of gravity are any how jumbled or agitated in water, the more ponderous always sink down below the lighter. I will give a complete instance of this in an artificial operation. The slime ore, or smaller grains which the water inevitably carries away with it in dressing the ores of tin and lead, &c. is saved in small ponds, or holes dug in the earth, in which the water that runs from the washing operation stagnates, and the slime carried with the water falls to the bottom. When these slime pits are full, the stream of water is turned off, and the sludge is thrown out to dry. The mineral washers have many nice and curious methods of dressing this sediment, in order to separate the heterogeneous particles from the metallic.

The best part of the tails (as it is called in the art of dressing ore) contains a great quantity of pyrites and other heterogeneous matter. Some of these tails they cannot clean by any stream of water, the heterogeneous being nearly of the same specific gravity as the metallic particles, and therefore they are obliged to take another method to clean it, which is called turloobing, or tozing, and it is performed thus:—They fill a large tub or vat about half full of water. A man of skill takes a proper shovel in his hands, with which he brings the water in the vat to a pretty quick circular

cular motion, and then one or two men begin to lift the matter, upon which the operation is to be performed into the vat, rubbing their shovel fulls against the inside of the tub, to the end it may fall into the water in a loose pulverized state. The man with the shovel continues to turn the whole round, and the others heave in the matter untill the vat is full, and then the shovel is drawn out, and they instantly take bats in their hands, and beat the outside of the vat with the battons for a considerable time, until the whole matter subsides in the water, and becomes consolidated into so hard a body, that it requires a sharp edged shovel to cut or pare it out. When the sords or water is thrown off, they begin to take out the matter, paring it away horizontally, and there we see the laws or effects of gravitation in the utmost perfection, and preserving the nicest exactness imaginable. A considerable quantity is thrown away off the top, and then they separate what contains any metal into several parcels, according to the quantity contained in each. As they come down to the good ore, they try it by vanning with a shovel to know when it is clean enough ; and I have seen half a ton of clean slime ore in the bottom of the vat. We cannot expect the same nice exactness in chance work ; however, particles of matter mixt and agitated in the waters of the ocean, and afterwards subsiding to the

the bottom, comes as near the tozing operation as any thing that can be imagined in nature or art ; of consequence, coal, and other distinct strata, could not be formed by subsidence in the waters of the ocean, without a miracle ; and I am not willing to admit or allow miracles to be introduced, where the operations of nature, and the agency of second causes, will do as well. I observed already, when viewing the coal metals, that the laws of gravitation were not consulted, nor admitted in the formation of those strata ; and therefore it is necessary for us to acknowledge that they were formed by the flowing of successive tides.

I have already made it pretty evident that the greatest part of the surface of the earth, before the deluge, was covered with a luxuriant growth of tall timber ; that this antediluvian timber is the origin of our pit coals, and that it was a sufficient and an adequate source of all the coals in the world. I am of opinion that the antediluvian timber floated upon the chaos, or waters of the deluge, until the strata of the highest mountains were formed, with much of the other strata in our sight ; and that during the height of the deluge, and the time in which the greatest part of the strata were forming, the timber was preparing and fitted for being deposited in strata of coal ; and that

that the coals, with their concomitant strata, were among the last that were formed. But how, and by what means, every thing in this great work was fitted and carried on, belongs to higher wisdom and intelligence than mine to explain. However, we may examine what we can see with our eyes, and what is to be seen we may investigate by the aids of philosophy; and it is allowable for us to draw such inferences as naturally and inevitable result from our observations and discoveries.

Wheresoever I have seen the strata of the coal metals terminate, and the strata of the mountain rocks commence in their place and stead, whether in the longitudinal line of bearing, or across the strata, the coal metals always ride uppermost,—are troubled, confused, and good for nothing, and commonly dwindled away to little in thickness; whereas, on the contrary, the strata of the mountain rocks emerge from under the disturbed coal metals in full perfection of quality, strata, and bearing, &c. and therefore I am obliged to conclude that the strata of coal, and their concomitants, were among the last which were formed.

I have frequently stood upon the summit of a high mountain in a clear day, and taken a general view of the outlines of this great subject; and from such elevated situations, and indeed every where else, I see deep and evident marks of the
amazing

amazing effects of the high diluvian tides, even after the higher mountains and other elevated parts of the earth were formed. All the long and deep channels through chains of lofty mountains, were cut out by the running of these weighty tides. All the gulphs and deep bays upon the face of the globe, were scooped out by the prodigious weight and force of the violent agitation and progress of the tides of the ocean from east to west.

A philosopher who is much out of doors, and traverses mountainous countries,—who admires these grand and magnificent scenes of nature, intent upon discoveries of truth, and who is not wedded, or rather enslaved to system, cannot fail of seeing the evident marks of these tides we are speaking of upon the whole varied face of the earth. The Mediterranean, the Red Sea, and all the other inland narrow seas, were cut out and produced by the violent progressive motion of those high and weighty tides. It was the weight and force of these prodigious tides, even after the mountains and elevated plains were formed, that has cut out all our sounds and deep channels between the continents and islands,—that has cut through the islands, and disseminated them over the face of the deep.

The weight and force of tides, which perhaps were several miles of perpendicular depth, have
made

made mighty efforts to wash away the whole face of the dry and solid land, and mix it again with the waters into a chaos.

The weight and force of these tides were so very great, that they have nearly cut a passage through the middle of both continents. In their progress from east to west, they have plowed up the channels of the Red Sea and the Mediterranean, which was a mighty effort to dis sever the old continent, and gain a clear passage to run quite through, and this passage was nearly completed; nothing but the narrow isthmus of Suez remaining to connect Asia with Africa. Similar marks and effects of these immense tides are as evident in the new continent as in the old. The gulph of Mexico upon the one side, and the bay of Panama upon the other, are sufficient instances to support this assertion, where nothing but the isthmus of Darien remains to connect North and South America into one continent. It is something singular and curious, that both the isthmus of Suez, and that of Darien, are very near the same breadth, being each of them about sixty miles over.

We shall attempt to throw some more light upon this great subject, by a few general observations. It was hinted before, that the gulphs were scooped out, the islands dis severed from the continents, and from one another, and the sounds

and

and channels were plowed up by the weight and force of the high tides, after the highest mountains, and other elevated parts of the globe were formed, and even after the tides were fallen so much as not to flow over the most lofty mountains and elevated plains.

In the height of the chaotic state of the terraqueous globe in the universal deluge, the tides flowed clear over every thing from east to west, without any obstruction; and even after numbers of the highest mountains were formed, the tides were still high enough to flow clear over the main parts of both continents, though not over the summits of the highest mountains; but when more elevated lands were formed, and the stratification of the superficies of the solid parts of the earth were pretty far advanced, the tides would then fall gradually and proportionally lower.

I shewed before, that the high tides, after the land began to be formed, purged the ocean of the earthy matter, and every succeeding tide laid more solid matter on the face of the ground; which was spread out in regular strata by the stream or flowing motion of the tides which brought it there. I also observed before, that all chains of mountains were at first elevated plains, and that it was very high tides flowing and running over them that had cut and differed

vered their summits, and excavated their glens and deep valleys.

The marks of forcible runs of water is evident in all the irregularities of the mountains. But all these primitive elevated plains were not cut through in a thousand places like our mountains, nor disfigured, but remain to this day; such, for instance, are the elevated plains of Abyssinia in Africa, of some of the south-eastern parts of Tartary or Buckaria, and the elevated plains of New Granada in America, all of which are countries of great extent, and raised higher above the level of the sea than our European mountains. If all the mountains were elevated plains at first, and if the elevated plains now mentioned are as high above the level of the sea as our mountains, how comes it to pass that these remaining high plains were not cut through and disfigured by horrid gulphs and valleys, like our rugged misshapen mountains? I answer briefly, the tides fell so low, by discharging and lodging much earthy matter upon the land, immediately after the formation of these elevated plains, that the water could not flow often enough over them to cut them asunder and disfigure them; and when the tides flowed over them no more, they could not be plowed up and broken to pieces like our mountains. But when all the highest mountains and the elevated plains ap-

peared at all times above water, and were no longer overflowed, not even by stream tides, it was then, when much dry land ceased to be overflowed by the tides, that the still comparatively high and forcible tides made such powerful efforts to cut through the continents and islands in all parts of the world. It is well known, that the tides rise high and run with great force in the torrid zone. The high chaotic tides would run with proportionally still greater force there than at present; and it is in the torrid zone that the greatest marks are found of those high and powerful tides. The diluvian tides rushing powerfully from east to west against the old continent, would be received and repelled by the elevated plains and chains of mountains, reaching from Abyssinia to the southern parts of Monomotapa, and they would be repelled to the north by numerous chains of mountains and high lands, stretching from Cape Comorin to the northern extremity of the Old Continent. When these chains of mountains and elevated plains situated to the south and to the north of the Red Sea, were now out of danger of being overflowed any more, the weight and force of the high tides of the Indian ocean then rushed powerfully against the middle of the Old Continent, where the land was not so high as upon both ends, and they have made sad havock of the low lands of the

the middle of the continent, and very nearly effected a passage quite through. The immense extent, and infinite number of the East India islands which are dislevered from the continent, and from one another, is a clear proof of the prodigious weight and force of the high tides of the Eastern ocean against the land. The effects of these tides against the east and south-east sides of the continents, have left deep and indelible marks of their powerful efforts : They have pushed far into the main land, in the gulphs of Siam and Bengal, and still farther in the gulph of Persia ; but they were every where repelled by high lands, until they came to Babelmandel, and there they entered the Red Sea, passed over the low lands of Egypt into the Mediterranean, and so quite through the Old Continent into the Atlantic ocean, and the high tides continued to flow through the middle of the continent until they fell nearly as low as at present ; and then this passage was shut up and barred against the common tides by the isthmus of Suez, and the main ocean was obliged to flow south about by the Cape of Good Hope, before it could come into the Atlantic.

While the diluvian tides continued so high as to pass over the land of Egypt into the Mediterranean, the run of the Mediterranean westward joining the tide of the main ocean upon its entering

tering the Atlantic, would make a very strong, weighty and powerful tide in the gulph of Mexico, and the effects correspond with our idea of the weight and force of these tides. The numerous and extensive range of the West India islands, and the gulphs of Maracaybo, Darien, Honduras, Nicaragua, and others, are sufficient proofs of the force of the Atlantic tides, and of their efforts to find or to cut a passage through the middle of the New Continent as well as the old. The later high tides passed over the isthmus of Darien in the New Continent, as well as over the isthmus of Suez in the old, and similar circumstances may be observed in both these passages. The New Continent is divided into two great parts, by the isthmus of Darien, in the same manner as the Old Continent is divided in two by the isthmus of Suez. The isthmus of Suez and of Darien, though in two different continents, and removed at such a vast longitudinal distance from one another, are nearly in the same parallel of latitude, which is about ten degrees north of the equator. It is evident, that when the land was mostly formed, and the tides were fallen considerably lower, though yet strong and violent, yet in this state they could not make way over the elevated plains of New Granada, and the lofty and extensive range of the Cordilleras and Andes, to the south of Darien, nor over
the

the immense and elevated countries of Mexico, and other parts of America to the north of Darien; and therefore, the isthmus of Darien, or Panama, was the only passage which the later high tides could find, for the ocean to pass through the middle of the New Continent, as it had passed through the middle of the old; but when the sea was thoroughly purged by the tides of earthy matter, and the dry land was all formed, the tides then fell so low by degrees, that they could not pass over Darien, no more than they could pass over Suez.

From the examination of these facts and circumstances, it is evident, and deserves to be remarked that the middle of both continents were at first formed lower than both ends; that is, from the island of Scotoro upon the east, to the bay of Cadiz upon the west of the Old Continent, was all low land, much lower than the extensive lands to the north and south of this low tract, over which the diluvian tides passed for some time after they were fallen too low to pass over the whole extent of the Old Continent; and in this Mediterranean passage the tides plowed a deep channel all the way through from east to west, excepting the narrow isthmus of Suez. The middle of the New Continent was also at first formed low land, as well as the old, and very nearly in the same parallel of latitude. The first
low

low plains in the middle of the New Continent seem to have reached from the island of Porto Rico to the bay of Panama, over which the strong confined tides made way, and cut a passage quite through the middle of the New Continent, excepting the narrow isthmus of Darien. It may be difficult to give a satisfactory reason, why the middle of both continents should at first be formed much lower lands than the two ends ; however, I will offer what occurs to me in explanation of this singular fact.

It is allowed by all, that the torrid zone, or the equator, is the highest part of our globe ; of course, the zone or girdle of the equator is longer than any other zone of the earth. This greater length of the zone gives the equatorial tides a greater length of space to pass over in every revolution, than in the other divisions of the globe ; and moreover, the torrid zone being under the perpendicular rays of the sun, the powers of attraction are greater there than in any other division of the globe.

When the land and water were blended together in the chaotic state of the deluge, the powers of attraction would raise the chaotic tides proportionally higher in the torrid zone, than in any other parts of the globe. The Cordilleras, and other exceeding high mountains, and the elevated plains of New Granada and Abyssinia, &c.
make

make it evident that the tides were exceeding high in the equatorial regions. These high tides having such a vast zone to encompass in equal spaces of time with the revolutions of the tides, without the tropicks, where the zones are much shorter, it is evident that the equinoctial tides must run with a stronger and swifter current than at the tropicks, and still much quicker than in the temperate and frozen zones of the globe. This is necessary from the nature of things. The revolutions of the tides being performed in the same length of time in all parts of the globe, the equatorial tides, which had by much the longest course, must of necessity run the quickest, in order to arrive at the goal in the same space of time as those in the shorter course. It is observable of a river in a land flood, that the middle of a stream or current runs or rushes forward boldly in a high and surgy ridge, and seems to hasten down to the sea, regardless of obstructions, which are frequently surmounted or swept away to the ocean. But the sides of the river in flood do not run quite so fast. The main head or current seems to cut its way, and pass through the middle of the river, which it leaves to follow at more leisure; and this is frequently so very evident, that eddies are formed in many places upon both sides of the main ridge or channel in the middle. We must
compare

compare great things with small, to enable us to conceive proper ideas of the great works of God. Let us then suppose, that the diluvian tides at the equinoctial line would rush forward in a high and bold ridge and current, like a river in flood, and then we shall be able to comprehend the reason, why the land is lower near the equator, than in the rest of the torrid zone upon both sides. The tides in this track would always run with a current too strong, weighty and swift, to allow mountains of granite and others to subside, or regular strata to be formed to any considerable height. But this bold and mighty run of the main current at the equator, would produce eddies at some distance upon both sides, where mountains of granite would subside; and strata would be formed by a more temperate and leisurely current and motion of the tides.

I observed already, that the chaotic tides rushed forward from east to west in two great gushes in the twenty-four hours; that the time of rest between each gush is high water, and the places of rest, the two great continents: I mean, during the height of the deluge, or chaotic state of the terraqueous globe. Upon this supposition, the tides in the intervals of each gush, at high water, would rest a little upon each continent, or at least, they would not rush forward so precipitately for some space of time at the turn of the tide.

This

This small and partial interval of rest, or of slower motion during the height of each tide, would be more considerable at some distance from the equator upon both sides, than immediately under the line, which intervals of time would not be lost. The formation of the solid land would advance rapidly in these times and places. But under the equator the tides would not have much time to rest, the intervals would be less considerable than upon both sides, and therefore the superficies of the globe was not formed so high in this great run of the tides over the Old and New Continents, as at some distance upon both sides. It was hinted before, that in consequence of these low parts in the middle of each continent, the strong tides towards the end of the deluge, which were not now high enough to flow over both ends of the two continents, passed for a considerable time afterwards over the middle of them, and rushed quite through from sea to sea. And these weighty and forcible tides have made terrible havoc in the middle, or near the middle of both continents. The Red Sea, the Mediterranean, and Black Seas, and the gulphs of Venice, &c. are sufficient proofs of the ravages of those tides in the middle of the Old Continent.

I suppose that the long chain of isles reaching from the island of Trinidad, upon the south-east,

to the Streights of Bahama, upon the north-west, were formed at first in one continued plain or regular connected piece of land of no great height, but containing however some considerable mountains, which still remain in St Domingo, Cuba, Jamaica, and in some other islands, but that the high tides of the Atlantic Ocean cut through, and dislevered them from the Western Continent, and from one another. When so much of our dry land was formed, that the tides did not rise so high as to pass freely over the ends of both continents, but still continued to run through the middle of them, there would then a strong and powerful tide pour into the Atlantic from the great South Sea, between the Cape of Good Hope and Cape Horn: and when this great and weighty tide was met and joined by the powerful current which rushed through the middle of the Old Continent, the united force and weight of both, when joined, would have powerful effects upon the lower parts of the New Continent. It was then that the long stretch of land reaching from the river Oroonoko to Florida, was plowed up and torn to pieces by the mighty efforts of those tides, to make a free passage through the middle of the New Continent, which was very nearly effected; nothing being left between the two seas but the narrow isthmus of Darien.

The

The debris or ruins, that is, the earthy matter which the tides plowed up and swept out of the numerous sounds and channels which separate the Caribbee and other West India islands, was carried by the tides over the isthmus of Darien, quite into the South Sea, where it subsided here and there in small patches, and formed the numerous small islands of the south sea, and some of the low plains of Peru and Chili. When those strong tides of the Pacific Ocean rushed between Cape Palmas and Cape St Roch into the Atlantic, the course of those tides in the Atlantic would be northerly or north-west; but when the Mediterranean tides, which issued out by Gibraltar, met and joined the tides from the south, the current from the Mediterranean would turn the weight of those tides to fall upon the Caribbee islands, in their way to pass through the gulph of Mexico, and over the isthmus of Darien.

The weighty tides which came between the two continents into the Atlantic, have cut deep into the land in many of the northern parts of Europe and America. The effects of these powerful and weighty tides upon the inside of the northern parts of the globe, are very evident in the many seas, bays, and gulphs which are scooped out of the bosom of the northern parts of both continents; but it does not appear that they found, nor that they made a passage quite through
the

the dry land in the northern parts of the earth. These tides might find low lands in the north, over which they might pass for a long time, as they passed over the isthmus of Suez, and of Darien; but, however that might be, I am persuaded that all the passages of the tides in the north are now barred up, as well as those further south.

I have seen the narrow isthmus at the north end of Cantire, which joins that peninsula to the main land of Scotland; and I have seen many other low and narrow bars between two seas or bays, over which the high tides I am speaking of passed freely; and I have every where observed, that these low and narrow necks of land consist of exceeding hard rock, which the most weighty and forcible tides could have no effect upon to wear them down; and this is the very cause which prevented the peninsula of Cantire, as well as many others from being islands.

This isthmus or rock which joins Cantire to the main land, is not above a mile over at high water in stream-tides; and I believe that the highest part of the rocky bar is not thirty feet above flood-mark.

The Buccaneers and other voyagers tell us that the isthmus of Darien in America is rocky ground; and I am certain it must be so, and that those rocks are very hard and strong; otherwise the forcible

cible tides which rushed from the Atlantic, over that isthmus, would have cut through and torn away this bar, and made a deep and wide channel between the gulph of Mexico and the bay of Panama. I know nothing about the natural history of the isthmus of Suez ; but we are well informed that Egypt abounds in excellent granite quarries ; and therefore, whatever may now appear at the surface of the ground in a country over-blown with sand, it is probable that there may be a bed of hard granite below the sand or soil of the isthmus of Suez, which prevented the heavy tides that passed over from the Red Sea to the Mediterranean, from plowing up a deep channel quite through the isthmus, between those two seas. I have taken particular notice of every narrow neck of land which I have seen between two seas, or between two bays ; and I every where found that they consisted of very hard and strong rock ; and I am confident, that every narrow isthmus in the world consists of very hard rock.

In short, there is no part of the surface of the earth that does not bear clear and indelible marks of the high diluvian tides in all the stages of the deluge.

The highest mountains of the globe generally consists of rough granite rocks. These were formed during the highest state of the chaotic tides. The highest mountains are found within
the

the tropicks or under them, but not immediately in the run or current of the tides near the equator; which suggests to us, that the main current of those tides was too strong, rapid, and constant, for the subsidence of such quantities of matter in a short space of time, as is required to the formation of ranges of high mountains, which would be formed nearer the tropicks, where there would be some eddies, and where the tides would not always rush forward with such force and violence. We observed before, that all the ranges of mountains between the tropicks trend from north to south, but the line of the mountains without the tropicks, upon both sides of the equator, falls a little back to the eastward; so that in Britain, and in parallel northern latitudes, the longest ranges of mountains trend from about S. S. W. to N. N. E. and they will fall back to the east proportionally in equal southern latitudes.

The elevated plains of Abyssinia, and the Mountains of the Moon, and others, in the interior parts of Africa, stretch in a continued range with very little interruption all the way south to the Cape of Good Hope. This great range trends due south, from about the fifteenth degree of north latitude to Monomotapa, when it inclines a little to the east, until it reaches the neighbourhood

bourhood of the Cape, in about the thirtieth degree of south latitude.

The northern great range of mountains and high lands of the Old Continent, commence somewhere about the latitude ten or fifteen north, and it stretches away due north through the Mogul Empire, and through Buckaria, until it joins the elevated plains of Independent Tartary, where they begin to lean a little towards the north-east; but in general, they still stretch away northward, with very little interruption, until it terminates in the extremity of the north. This is still a longer and more extensive range than that which trends away south through Africa. The great range of the Asiatic mountains is not only of immense length from south to north, but it is also of great breadth from east to west, though with considerable interruptions, which in fact divides them into several ranges. The European great range of the Alpine mountains stretch away north from Monaco, upon the east side of the gulph of Genoa, through Savoy, Switzerland and Germany, and with some little interruption, continue a northern course to the extremity of Lapland; but with an inclination to the east of north. The principal range of mountains in the island of Britain, keep the same general course from north to south, with a lean towards the north-east. This range commences in Caithness,

ness, in the northern latitude of fifty-eight, and it stretches southward through the countries of Sutherland, Ross, Inverness and Argyle, and this western division of the range seems to terminate in the island of Arran.

The eastern column or division of this greatest range of British mountains, commences in Banff or Aberdeen-shire, in the north latitude, about fifty-eight, and in about one degree of west longitude from London, and stretches southward through the counties of Aberdeen, Angus, Perth, Stirling, Dunbarton, Renfrew, Ayr, Galloway, Cumberland, Westmoreland, Lancaster, Flint, Denbigh, Merioneth, Montgomery, Cardigan, and it terminates in Pembroke-shire in South Wales, in the north latitude about fifty-one, and in about five degrees of longitude west of London. The interruptions in this range are not great.

The American ranges of mountains likewise trend from south to north. The highest mountains upon the face of the globe are those of South America, and among these the Cordileras are distinguishable, for their vast height, magnitude, and extent.

The principal range of the mountains of South America commence in the mountains of St Martha, in about the tenth degree of north latitude. The mountains of St Martha join the elevated
plains

plains of New Granada, and stretch away due south in a lofty magnificent ridge, parallel to the west coast, all the way to Patagonia, and with very little interruption to Cape Horn, in about fifty-five degrees of south latitude. This is a very long, high and regular range of mountains, stretching from north to south, with a little inclination to the east, as they advance south through Chili and the Terra Magellanica. The mountains of North America, though more extensive, are not so regular and lofty as those of the south; and therefore the ranges cannot be so distinctly traced out. The Apalachian mountains, which commence about the 30th degree of north latitude, trend away northward through Canada and Labrador, and perhaps through Greenland, with the interruptions of Hudson's and Davis's Streights. This is a considerable range of mountains; but I suppose that the most considerable and extensive range in North America, are those which stretch along the west side of the continent, not far from the west coast, from about the twentieth degree of latitude to the extremities of the north, and north-east, where America joins the continent of Asia, an extent of more than four thousand miles.

Many philosophers and naturalists assert, as an established fact, that all ranges of mountains run from east to west; but this assertion is founded

upon very limited and imperfect views of the subject. I grant, that from a cursory and partial view of the mountains of all countries, they do appear at first sight as if ranged from east to west ; but this is a hasty conclusion from a cursory view, without investigating the subject. The running of the high tides from east to west, over the ranges of mountains, have plowed and scooped out the glens, the channels and valleys in that direction ; and by that means dis severed the mountains from one another, into ridges of different lengths, running from east to west ; but this is only the marks and effects of the diluvian tides, running at first over those high lands, when they were elevated plains ; the prodigious weight and force of which tides plowed up and tore those plains to pieces, washed away the earthy matter out of the glens and excavations, and left them as we find them in the form of mountains and glens, rocks and precipices, of which there is an almost infinite variety. But that the mountains in general really are ranged from north to south, I have produced sufficient instances to prove the fact to a demonstration.

When the high tides of the great South Sea would fall into the Atlantic ocean, through that wide and ample entrance between Cape St Roch, on the coast of Brazil, and Cape Palmas, on the coast of Guinea, after most of the dry land of
both

both continents were formed, those high and weighty tides would rush powerfully against all the shores of the Atlantic.

The Atlantic ocean is really a gulph of vast magnitude and extent; round the north end of which, there are a number of subordinate gulphs. The sea between Cape Palmas and Cape St Roch, is the only entrance in and out of this gulph, either for the tide or for ships. There will be a great tide in the Atlantic itself, independent of the South Sea; however, these tides must be inconsiderable, when compared with those of the great Pacific Ocean.

The great height of the mountains of Peru, is perhaps the best means or helps that we have to assist our ideas in forming proper and adequate conceptions of the prodigious height of the diluvian chaotic tides, before the surface of the post-diluvian earth was formed. The Cordilleras in Peru are said to be four or five miles of perpendicular height above the level of the sea. This may be called, and it really is a great height above the common surface of the earth and sea; however, I suppose, that this height is but small in comparison of the first diluvian tides. I have before hinted at the natural causes of the prodigious height of those tides. The great height of the diluvian tides would diminish gradually in the course of time, in proportion as dry land was formed.

formed. I observed and explained before, that the ocean actually purged itself by the tides, of the loose earthy matter, in proportion as more dry land was formed, which tended to sink the bed of the ocean, and gradually to sink the tides. If we suppose, that the first great diluvian tides were eight or ten miles high, before the mountains and elevated plains of the earth were formed; we may suppose, that tides of near half a mile in height, would fall into the Atlantic gulph from the great Pacific Ocean, for a considerable time after most part of both the continents were formed. These high and weighty tides would fall with prodigious force upon all the shores of the Atlantic, and its subordinate bays and gulphs; and in fact, we see evidently, that the tides of the Atlantic have made terrible havock upon the shores both of the Old and New Continents.

The course of these high tides from the Pacific Ocean into the Atlantic, would run nearly from south to north. When these tides were advanced as far forward between the two continents as the latitudes forty, fifty and sixty north, they would then fall with great weight and force upon the eastern coasts of North America, and we there see very evident marks of their great effects in the many islands, sounds, gulphs and inlets, which are found upon the eastern coast of America. These tides seem to have fallen particularly

ly heavy upon those coasts to the north of the latitude forty, as may be seen by Hudson's and Baffin's bays, and the many other deep bays and gulphs upon that coast; and it is highly probable, that these tides found some low lands, and passed at first over the northern parts of America, as well as over the isthmus of Darien.

When these Atlantic tides were advanced forward to the above-mentioned latitudes, they would not only press hard upon North America to force a passage over or through that continent, but they would also push forward in a direct line from the mouth of the great Atlantic Gulph, which is under the equator, and fall with excessive weight upon the northern coasts of Europe; and there we see great and evident marks of their prodigious effects and ravages in the indentings of the northern coasts; and they have made powerful efforts there, to force a passage quite through between the Old and New Continents, which, however, was not completed. These tides might pass over some low valleys to the north and east, as they did over Suez and Darien; but they did not complete a passage quite through so low as the present level of the sea, which is now made perfectly evident by the researches and discoveries of the celebrated Captain Cook.

The high tides of the Atlantic, when advanced as far north as our latitudes, when near high water,

ter, would fall back to the eastward, and rush down with force and violence upon the western coasts of the British islands, the coasts of Norway, and other parts of the continent of Europe.

We have now brought our observations nearer home, where circumstances can be seen and investigated by every inquisitive man who is searching after truth. The ravages of the sea upon the western isles,—the indentings of the west coasts of Britain, Ireland, and Norway,—and the bays, sounds, channels, and inlets of the western and southern coasts of Europe, are clear and convincing proofs that a great weight and force of water has operated powerfully and effectually upon those coasts. It was then that the British Channel was cut through between France and England by a strong and weighty run of the high tides from the Atlantic into the German Ocean. It was then that the western islands were dis severed from the main land, and from one another, and the various sounds and channels were formed ; and it is very probable that it was then that the Baltic Sea, with all its gulphs and indentings, was scooped out of the low lands of the northern parts of Europe. Let any man who impartially searches after truth, examine the map of the west coasts of the British islands, &c. and then let him reflect upon what he has seen of those coasts ; and he must of necessity be convinced, that high, weighty, and

and forcible tides have made powerful efforts to work out numerous passages through every district of those coasts ; and in many places their efforts have been effectual in dissevering one island from another, and forming the sounds between them, in scooping numerous deep bays and gulphs out of the bosom of the land ; and in several places a narrow low bar of hard rock was interposed to prevent those tides from cutting quite through, and joining two bays or inlets in one sound or channel. Numbers of these narrow necks of land are to be found in all parts of the world.

Before I dismiss these speculations upon the outlines of the superficies of our globe, I will beg leave to remark, that I perceive some phenomena and some facts which I cannot account for.

Most of the dry land of our globe is situated to the north, and the lowest parts through the middle of each continent, at the isthmus of Suez and of Darien, which appear to have been the principal currents of the high equatorial tides, are considerably to the north of the equator ; but I cannot perceive the natural cause why it should be so.

It is acknowledged by all intelligent men, that the Old Continent is much bigger than the new. Some say that it is more than twice as big ; however, the late discoveries of Captain Cook upon the west coast of America, make it evident, that the northern parts of the New Continent are much

much larger than was formerly supposed. But what may really be the different comparative extent of each continent, I cannot determine. However, it appears, that of the Old Continent, all Asia and Europe, and more than one half of Africa, is situated upon the north side of the equator, and of what properly belongs by situation to the old part of the known world, nothing but the lesser half of Africa, with New Holland and some lesser islands, has been yet discovered to the south of the equinoctial line; and I am persuaded that there is not much more to be discovered. Matters are not much different in America, with respect to the disposition and situation of the dry land. America is considerably longer from north to south than the Old Continent.

The south end of Patagonia, which is the southern extremity of the continent of America, is laid down by Geographers about twenty-five degrees farther south than the Cape of Good Hope, which is the south point of Africa, and the great island of Terra del Fuego is still farther south than Patagonia. But although America is much longer from north to south than the Old Continent, it falls very much short of the breadth of the old from east to west. But whatever may be the different proportions of the extent of the surface of both continents, it appears that there is more of the New Continent situated to the south
of

of the line than there is of the old. But although there is such a small proportion of dry land in the southern hemisphere, the highest mountains in the world are found upon the south side of the line. The Cordilleras in South America are by far the highest mountains in the world; and I suppose, that they are the most magnificent connected ridge of mountains any where to be found. 'The elevated plains in the middle of Africa' are of great height, but very little known, as are mostly all the interior parts of that quarter of the globe. The Mountains of the Moon and of Monomotapa, to the south of the line, are erected upon these high countries, like so many lofty towers built upon an eminence, which must raise them a prodigious height above the level of the sea.

This chain of mountains is of great extent from north to south, stretching from the line into the southern parts of Caffraria; and it is highly probable, that the end of this chain, which is situated next the equator, are the highest of any mountains in the Old Continent.

It is well known to naturalists, that fluid bodies, especially water, are attracted and put in motion by the influences of the Sun and Moon, which undoubtedly is the cause of the tides of the ocean. This being well known, it must of consequence be granted, that the greater the ex-

tent and depth of water exposed to the heavenly influences, the greater will be their effects, and the higher the tides will be raised.

From this consideration, we are led to conjecture, that in the height of the chaotic state of the deluge, there was less earthy matter mixed in the ocean to the south than to the north of the equator; and consequently, the tides would be raised highest upon the south side, which is the cause of the highest mountains being found in the southern hemisphere. But why there should be more earthy matter upon the north than upon the south of the line, we have no foundation so much as for a conjecture.

All the external phenomena of mountains are easily accounted for, from the consideration of the direction and forcible currents of the tides, which flowed over the land during the formation of the strata. It was then by those high and forcible tides, that the long channels were cut through the mountains from east to west; through which channels, strong and weighty currents ran from sea to sea, many of which are now dry land far from any tide:—it was then that the concavities and gulphs among the mountains were scooped out by the violent whirling motion of the waters in all directions, which now give the excavations of the mountains such various deep and gloomy forms:—it was then
that

that precipices were formed and rocks undermined, by a strong and weighty current running forcibly under the side of a mountain, and washing away the one side of it, before induration was compleated, or even far advanced:—it was then that single, and singular rocks of antic and grotesque figures were formed, by the tides washing away their basis, and retreating before the whole fabric was demolished. All countries produce instances of these singular antic rocks, but some of them are more remarkable and extraordinary than others. Many of these are quite undermined, and project their horrid fronts, and threaten to overwhelm all who approach them. In short, the marks of water are every where visible, and easy to be discerned among the mountains and rocky shores of the ocean. But all these gulphs, bays and inlets, which seem to disfigure the face of the earth, are not however to be considered merely as blemishes of nature. In truth, they are great and necessary perfections, highly conducive to the good of the world. A commercial state of the world, by which the mutual wants and conveniencies of all are reciprocally received and returned, is undoubtedly the most happy and perfect state of society, and the ingulphed situation of the numerous Mediterranean seas, and the “nook-shot-ten” figure of the earth is undoubtedly the most convenient

convenient for commerce, as, by this disposition of things, the commercial ships sail into the heart of the continents, and carry in and out goods, which could not be carried thousands of miles by land.

Let us take a cursory view of the face of the globe, and consider the disposition of things in a social and commercial light. There are but two great seas in the world, viz. the Pacific and the Atlantic oceans; and it may be observed of these, that the first is situated upon and all round the outside, and the other within the bosom and center of the dry land; so that by navigating the Pacific ocean, we can go round about and visit all the outer boundaries of our inheritance, the earth, and by navigating the Atlantic, we can penetrate into the bosom and center of the earth in a thousand places. The course and progress of commerce has always been from east to west, and from the center towards the circumference. Commerce began in Asia, but its chief seat at present is in Europe; and Europe is the best situation in the whole world for commerce, when taken in an extensive view. The course of foreign commerce is to go out of the Atlantic or great commercial gulph, into the Pacific, which is the great commercial ocean; and in this route we must pass between Brazil and Guinea, and forward to the left by the Cape of Good Hope, or
to

to the right by Cape Horn. In pursuing the left hand tract, we come to the fertile, rich, and extensive countries and islands of Asia, where we exchange our own commodities for the rich fruits, the rich spiceries, and the rich stuffs of the east, which must come home by the same route. The western coasts of the best part of America being in the hands of the Vandalic Spaniards, perhaps originally Tartars, who improve nothing, there is as yet but little to excite general commerce to pass through the Streights of Magellan, or to double Cape Horn.

When we come again into the Atlantic, which may be called our greater Mediterranean, and glance at the disposition of things, for the convenience and advantage of commerce, what benevolent heart will not overflow with gratitude and admiration of the supreme wisdom and beneficence, in disposing all things for the general good! It is here that we clearly perceive the wise and benevolent designs of the Creator, in controlling and directing the very rage of the elements for the good of the universe, or in other words, for commercial convenience; which is the means of the greatest prosperity the world is capable of.

The rage of stormy winds exciting the violent motion and force of the diluvian tides to tenfold fury, which has tore out the very bowels of
the

the land in a thousand places, into gulphs, founts, and Mediterraneans, and endeavoured to sweep away the whole face of the dry land, and mingle it again with the waters into another chaos. "But all things shall work together for good,"—for this fury and ravage of the elements has formed our great navigable canals for commerce, which (O happy Britain!) diverge every way from thy fortunate island, like radii from a common center; and thy ships are continually sailing to the west and to the east, to the north and to the south, upon these commercial canals, which are ready prepared for thee by the universal Patriot and Founder of happy situations, and of happy states.

The British islands, though far north, are situated in the center of the universe in respect to commerce. The British merchant carries out by the Cape of Good Hope the produce of our island, improved by the labour and skill of our artificers, in exchange for which he brings home rich merchandize from afar. He sails westward with abundance of our produce and of our commodities, and brings home the rich and comfortable productions of the new world.

To the south-east, he traverses the great length and many windings of the Mediterranean, to dispose of the manufactures of his country, and to bring home many of the comforts of life.

To

To the north-east, he goes to Archangel for timber, and up the Baltic with some few of our commodities, for timber, hemp and iron, the last of which might be made at home, to supply ourselves and others. To the north and north-west of Europe, the British merchant carries out but little, yet he makes profitable voyages. He finds the extensive northern gulphs replenished with whales and other valuable fish, by which himself and his nation are enriched. The British merchant goes to the inhospitable shores of Hudson's Bay, and many other cold and barren regions, and brings home the fine furs of the north for the comfort of our fine ladies, and lady-like gentlemen.

Thus, the high diluvian tides, and the rage of the elements, have torn and intersected the bowels of the continents and islands, for the general good of man in a social and commercial state.

The Atlantic ocean is a great basin formed in the center of the habitable world; from which great basin, a great number of canals and channels are cut out every way, to water and enrich all countries, with plentiful exhalations dissolved in rain, and with the reciprocal benefits of commerce. Two of these are eminently distinguishable above the rest, for extent and general utility, viz. the gulph of Mexico, with all its subordinate gulphs and bays, in the New Continent ;

continent; and the Mediterranean, with the Black Sea, the Gulph of Venice, and all its other gulphs and bays, in the Old Continent; and these two great branches of the Atlantic have nearly cut through both the continents.

Would it not be a great convenience and advantage to the commercial world, if these two narrow bars were cut through by the art of man?

It is said, that Alexander of Macedon meant to cut through the isthmus of Suez, for the reciprocal convenience of the commerce of India and the Mediterranean. Would it not be a great convenience to the world, and a general advantage to the commerce of Europe, if the isthmus of Suez and of Darien were cut through, to make a ready communication from sea to sea in both places? I grant, that such a ready communication would be an immense advantage to the commerce of Europe, and of all nations; but what is generally understood by a navigable cut is absolutely impracticable; a navigable canal with locks is practicable, but how far convenient circumstances may concur to favour the execution of such a work, as a navigable canal over either of these two places, I do not know. It is a pity that the isthmus of Suez has so long been and still is under the dominion of those barbarians the Turks, a species of Tartars or hereditary

tary barbarians, who will do nothing for the good of the world, or for the general benefit of society and commerce. Was the isthmus of Suez in the hands of a wise and intelligent power, I should imagine that a canal with locks, upon a sufficient scale to carry through ships of all burdens, would be soon executed; and the ships of all nations passing through and paying a moderate toll, would soon reimburse the expence, and produce a valuable revenue to the State; but such are the mutual jealousies of the power and prosperity of all nations, that there is little room to hope for such a public benefit.

The commercial part of the world in general, are not so much interested in the isthmus of Darien as in that of Suez. However, a navigable canal over Darien would be a great convenience to the countries of Peru and Chili, and likewise to California, and all the west coast of North America, between California and the bay of Panama. But while all these coasts lie under the dominion of their present oppressors, there is not much hope that those naturally glorious and fertile countries will ever be favoured with such a spring and impulse to industry and commerce, while the Spaniards are the inactive, but cruel lords of such fine and improvable regions of the earth.

We observed above, that the amazing weight and force of high tides, even after the higher

grounds were formed, made numerous deep and wide runs and channels through the chains of mountains and higher grounds, before induration was compleated, examples of which may be found in Britain.

Such, for instance, is that betwixt Fort-william and Inverness,—between the Frith of Clyde and the Frith of Forth,—between the Solway Frith and the North Sea, to the east and south of Berwick upon Tweed,—between Parkgate and several parts in the north-east of England, and between the Severn Sea at Bristol and London; and it highly deserves to be remarked, that several of the widest of these channels were afterwards filled up to a certain height with the strata of coal and coal metals. Each of the natural channels or runs of the tides just mentioned, excepting that between Inverness and Fort-william, are really filled up with coals and the concomitants of coal. The truth of this observation is obvious, and will bear every enquiry; but I will not enlarge upon it; only allow me to remark, that the wisdom and provident goodness of Almighty God shines conspicuously in this disposition. The rich and pleasant valleys, and low plains near the seas and large rivers, were to be the habitations of the social, commercial, busy world of mankind; and there the coals are found, perfectly convenient for home consumption,

tion, and for supplying the wants of others, by the great commercial high-roads, the waters. Had the coals been deposited in the bowels of the highest mountains, they would in a great measure have been useless to society, manufactures and commerce. We could not have carried the coals from the distant mountains, nor lived near them. The high mountains are too barren, too cold, and too far from the seas, for the residence of man in a social commercial state; but there is none or very little of them there. I have neither seen nor heard of coals being found any where in very high mountains; however, I do not assert the contrary; such a thing may exist in some part of the world or other, though I am of opinion, that there is no such thing as real and regular strata of coal in high mountains. None have yet been discovered in such situations; and therefore, we may assert, that the thing is not common. In the common course of things, matters are better ordered for our convenience. We generally find the coals in low valleys, and in easy rising grounds or low hills, in situations where the dwellings of men and their manufactures are pitched, and seldom very far from the seas or navigable rivers. He who formed the earth knew all his works from the beginning, and what use every part of it was to be turned to in every age of the world; and therefore,

therefore, every part was fitted for the scenes to be acted upon that particular stage.

Great Britain could never have been such a manufacturing commercial country as it is, had it not produced such abundance and variety of metals to be manufactured, and such abundance of excellent coals as are found and worked, with which our metals are manufactured. The precious and useful metals are frequently discovered in pretty high mountains and remote situations; but their great value in proportion to their bulk, enables us to work them, and to carry them to the manufacturing and commercial parts of the country. Coals, on the contrary, must be a cheap commodity in proportion to its bulk, otherwise it would never answer for the furnace, the forge, nor the kitchen. As a vast bulk and considerable weight of coals is used for all common purposes, the price would become too high before they could be brought down from the mountains to the cities and habitable valleys.

The more I look into the Mineral Kingdom, the more clearly I discern the wisdom and providence of our beneficent Creator! Many wise and worthy philosophers have given us numberless clear and convincing proofs of consummate wisdom, benevolence, and design, in fitting all animals and plants for their respective purposes, situations, and manner of living. Many excellent

lent observations have been made upon all parts of the animal and vegetable kingdoms ; and I am persuaded, that in time, there will be as much said upon useful subjects relating to the Mineral Kingdom, and as much to the purpose. I know well that there is as much to be said. The most necessary articles, to supply the wants and to suit the conveniencies of man, from the Mineral Kingdom, are found in the greatest plenty, and are the easiest to be procured : Witness pit-coal, iron, building-stone, limestone ; but I will not descend to particulars. The field is too extensive for me. In time it will be cultivated. It will be thoroughly known and acknowledged in the course of time, that there are as clear footsteps of a wise and benevolent Creator discoverable in all parts of the Mineral Kingdom, as are discovered in the animal and vegetable ; and I reckon all the characters and circumstances relating to coal and ironstone, which was the subject of our enquiries above, to be eminent instances of benevolent wisdom and design. When future naturalists shall lay the foundation of their researches in the Mineral Kingdom upon true and rational principles, and shall discover clear demonstrations of the wisdom and designs of providence in the formation of the surface of our globe, and in the respective disposition of all fossil and mineral bodies, they will not then be offended at the leading, though rude observations of a rustic philosopher.

They

They will rather thank him for the trouble he has been at in clearing the ground, and laying this rude foundation for their future profit and pleasure in mineral studies.

I will now offer a few observations concerning the mutations of our globe. In the two last general heads, I pointed out and explained several clear and incontestible proofs of an universal deluge. The observations I mean to advance at present, derive their force and importance in a great measure from their connection with, and relation to my former observations, in proof and illustration of the doctrine of the deluge.

My remarks upon the fragments of quartz, shirl, and mica, &c. will in time appear to the candid and intelligent, to be decisive proofs that they are fragments of some original strata, which strata we can no where find; nor can we give any account or rational conjecture about them, without allowing of what was universally believed by all antiquity, and celebrated by many of the most ancient poets and philosophers of many nations. I mean the primæval state of the earth before the deluge.

I reckon it a certain fact, that the quartz, shirl, and mica, with all the fine grains found in the composition, and in the decomposition of our rocks and strata, which are not of a prismatical figure,
are

are fragments and remains of the antediluvian strata; and I think it probable, that all our metallic and mineral ores were disposed in strata in the antediluvian state of the earth. I think it probable, that the metals were all originally in a pure and malleable state; and that the strata of original metals, as well as all others, were broken to pieces, and mixed with the waters in the chaotic state of the terraqueous globe; and that by the motions of the tides, they were all ground down to small grains and particles, which were afterwards mineralized, or mingled with heterogeneous mineral matter, before these compounds were deposited in our mineral veins, and in the composition of some of our strata.

A great deal might be said about the origin of the antediluvian strata; but as it must all be hypothetical, I will not dive into such uncertain and useless conjectures. But notwithstanding this resolution, I would not have it understood that I give up the point as uncertain. I have made it abundantly evident, that such strata certainly did exist. I hinted before, that the various fine grains and fragments which are found in the composition of our strata, have all the appearance and characters of originality. The atoms or particles which compose the finely laminated textures of the masses of talc, must be inconceivably small.

We

We can divide the plates or laminæ of talc into an inconceivable degree of fineness. What sort of particles then must such bodies be composed of? and the other grains seem to be equally fine. If we should decompose any of these bodies, and look for the original particles which compose and make up the mass, I suppose we should not be able to discover them. We should find them evanescent; but our strata are not so. If any of our strata are decomposed, we can discover and give an account of the component parts, which are quartz, shirl, mica, and various other fine and pure grains; but if we look for the atoms which make up these fine grains, we shall find them evanescent in our hands.

The inconceivable fineness, and homogeneous purity of the whole mass of these original fragments, suggests to me one remark, which I beg leave to offer, viz. As there are no perceptible grains or particles in these fine fragments, it is evident to me, and will appear evident to every candid enquirer into these matters, that our globe has suffered only one great change by water, or otherwise. These original fragments do not point out to us any thing whatsoever that might suggest the idea of several deluges, or of the earth having suffered several great mutations by any means whatever. The component parts of our rocks
and

and strata, clearly point out to us the necessity of acknowledging that our globe has suffered one great change by water; but the phenomena of nature go no further. We are obliged to acknowledge, whether we are willing or not, that this one change was accomplished by the agency of water; for it is now very generally known, that the marks of water are conspicuous all over the superficies of the globe. The fineness and purity of the essence and quality of these original fragments, not only suggest to us, that the earth has suffered but one change, but they also point out to us an ocular demonstration of a revealed truth, viz. that the Almighty in the beginning created all things out of nothing. Moses speaks of "all things which 'the Lord God created and made;'" and there appears to me a notable distinction between the word *created* and the word *made*. The idea we have of the meaning of the word *create*, is to bring something into existence which had no being before; but our idea of the word *make*, or *made*, is the exercise or effects of a mechanical operation, whereby something is formed of pre-existing materials, agreeable to the design and skill of the maker.

When the great philosopher Moses says, that the Lord God created the heavens and the earth, and all the hosts of them, the word *create* seems

to me to point at the act of the almighty will and power in the first production of matter ; and the word *made* seems to point at the proper use of matter in the formation of worlds, animals, vegetables. But these are depths not to be sounded by me, and therefore I will only touch them lightly ; however, I cannot help thinking that the fineness and homogeneity of the original particles of matter justifies my saying so much.

Again, we are told by Moses, that in the beginning of the creation, or of making the earth, and while it was yet without form, " The Spirit of God moved upon the face of the waters." Perhaps we may here understand by *Spirit*, wind, or air in motion, as an agent, which suggests to us, not only the idea that the antediluvian earth was formed by the agency of water in motion, but also, that this agent operated in a smooth and orderly manner. The atoms which composed the ancient strata were inconceivably fine, and they were as finely put together, as plainly appears by the fragments of them which we see, which exhibit the most perfect stratification ; and we may observe, that fine materials are capable of being finely fabricated ; and they deserve it. But I will return to the examination of the component parts of our strata, where I can walk upon more sure ground, than in disquisitions about the ancient strata. It appears to me highly probable,
that

that our metallic ores were all in a pure and malleable state, and disposed in regular strata in the antediluvian earth ; and that these strata, as well as others, were broken and ground to pieces in the violent motion of the waters of the deluge ; and that they were mineralized, or mingled with heterogeneous particles before they were lodged in our veins, and in the composition of some of our strata.

That a considerable quantity of mineral and metallic ore is blended in the composition of some of our strata, is evident. I have frequently seen it, and what I have seen, no doubt but many others have seen also.

Gold is chiefly found in grains of various sizes, mixed in the composition of many rocks, though not in a mineralized, but in a pure and virgin state.

Iron is commonly found in the composition of a great number of rocks. I have seen lead blended in the composition of the strata in many places. For instance, there is a stupendous rock at Cwmlog in Cardiganshire, Wales, which, to a great extent, is mingled with grains and flowers of fine blue lead ore, where I saw a great number of miners scattered upon the high front of the rock, most of them suspended by ropes, blowing down the rock with gunpowder, in order to separate the lead from it. I have frequently seen copper

per in the body and composition of the strata in many places. The tin grains in Cornwall, found in the composition of a species of granite, is another instance; and these few are sufficient to prove the fact.

If there was no pure virgin metal found in the world, my supposition of the ancient state of the metals would be more doubtful; but as there is a good deal found in that state in many parts of the world, this circumstance favours my opinion; and moreover, it is a remarkable fact, which is worthy of attention, that the quantity of pure virgin metal found in a malleable state, is in exact proportion to its toughness and ductility.

1. Gold is found in small masses, and in grains of various sizes, but always in its virgin malleable state, embodied and blended in the composition of the rocks, and mingled in the sands of rivers and rivulets, from the decomposition of those rocks. I hinted before, that there being some virgin metals found in the present earth, countenances the supposition, that they were all pure and malleable in the antediluvian earth; and I will now add, that the manner in which they are found corroborates my opinion.

Virgin metals are most commonly found either in small grains, blended as part of the composition of the strata, or else imbedded in stones, or in cliffs of rocks, and often squeezed by the pressure
of

of the surrounding rocks, so as to give the larger masses a rough, unequal surface, being the exact impression of the bed they were found in. This figure is given by forcing the pliant metal into all the irregularities of the rock, like a print of butter. But grains and small masses blended in the composition of the strata, is the most common state of the virgin metals.

2. There is more silver found in a pure and malleable state, than of any other metal, excepting gold. I suppose that the tough and ductile property of gold is the natural reason of its not being broken smaller by the attrition of the fragments of rocks in the agitation of the chaotic state of the deluge; and it is remarkable, that silver is next to gold for toughness and ductility, and accordingly, the proportion of each found in a pure virgin state, corresponds exactly with these properties. In some of the silver mines of Mexico and Peru, the silver is found pure in the masses of ore. By viewing samples which I have seen from thence, the silver appears rather blended in large grains, and small fragments of virgin silver, with other mineral substances in the general mass of the ore, than mineralized like our blue ores, which are rich in silver. In the American ores we can see large grains of silver with the naked eye; and as an unquestionable proof that we are not deceived, we can cut them with a knife; whereas

whereas, in our mineralized ores, which are rich in silver, the particles are so small, and so perfectly blended and mineralized, that we cannot distinguish them even with the help of glasses.

3. Copper is more tough and ductile than lead, and less so than silver; and accordingly we find more pure malleable copper, than of lead, and less than of silver.

Whether the learned naturalist will agree with my opinion concerning the ancient state of the metals or not, he must acknowledge, that this series and gradation which I have pointed out countenances my opinion. There must be some reason for this gradation, and I think he cannot point out one that corresponds so well with the phenomena of the composition of the strata; and therefore, I really think that I might have ranked the metals with the quartz, shirl, and mica, as being equally evident fragments of original strata.

I suppose that this hint is new, as well as many others in these papers; and therefore, no doubt but they will startle such naturalists at first, as have not been accustomed to view these subjects in the same light with me; however, I hope it will be acknowledged, that my observations are founded in nature, and I declare that it was not the affectation of novelty, but the love of truth, that prompted me to communicate them

to

to the public. The phenomena of nature have pointed out to me such observations as may have an air of novelty. I submit them to the examination of the candid naturalist, and when he has thoroughly and impartially examined my works, he will acknowledge that truth is on my side.

Naturalists have been greatly puzzled to find a quantity of water sufficient to cover all the earth, to the depth of about forty feet above the summits of the highest mountains, so as to produce an universal deluge, as described by Moses, and I confess it is a puzzling subject. It is still as difficult as ever, to find a quantity of water sufficient to make such a deluge as the most of them have contended for. Some of them have laboured hard in search of it, and they have ransacked Heaven above, and the lowest parts of the earth, to collect such a quantity upon the face of the globe as would deluge the highest mountains; but their researches have not been effectual; and their account of this matter is by no means satisfactory, nor can I give them any assistance. I do not know where to find a sufficient quantity to cover the whole face of the globe to the height of the lowest mountains, if we allow those mountains to remain firm and stable as they now are.

It is out of nature, and appears to me impossible without a miracle. But if we suppose, that
the

the original strata of the antediluvian earth were some how or other dislocated, broken to pieces, and mixed with the waters of the ocean in a chaotic state, then the difficulty is removed, by removing the mountains, and mixing them in a chaos with the waters. In this view of the subject, there were no mountains to be covered, until they were afterwards formed by the high tides of the deluge; concerning which, I will offer a few observations. The quartz, shirl, and mica, and in short, all the visible fine grains found in the composition of our present strata, are clear indications, and strong proofs of the former existence of such original strata as I speak of. At the same time, it does not appear to me an easy matter to explain how those original strata were broken down and mixed with the waters. The ancient philosopher and inspired historian Moses, acquaints us, that there was no rain in the antediluvian earth, but that the face of the ground was watered by mists instead of rain, which is not improbable. There are some countries which never rain in the present state of things; such, for instance, as Egypt in the Old Continent, and Peru in America; and moreover, we frequently see thick mists in these countries. A thick mist arose from the north-east in the summer of 1780, which was carried along by a considerable, though moderate breeze of wind. This mist was
fo

so thick and heavy, that it condensed against the south side of the High Street of Edinburgh, to such a degree, as not only to make that side of the street wet and dirty, but even to run down the gutter in a current as in time of moderate rain, while the middle of the street and the north side were dusty. And I saw the same mist, when carried by the wind, condense against the leaves of trees, so as to run off the trees in continual great drops, which made a puddle under them, and it ran along the side of the road, where there was a row of trees, while a cloud of dust was flying in the middle of the road. I saw this in several parts of the Lothians in Scotland. Upon the supposition of there being no rain in the antediluvian earth, the strata which composed the superficies of that earth would want moisture, and of consequence they would become full of cracks and chaps by drying too much; the dry external air would be admitted into their cracks and fissures, which would waste the cohesion of the rocks, and hasten their decay near the surface.

The rains descending seasonably upon our mountains and plains, entering the superficies of our strata, and percollating their pores and crannies, and passing through their interstices, keeps them continually fresh, and preserves the cementing quality in perfection. But if the antedilu-

vian strata wanted the moisture communicated by rain and melted snow, undoubtedly they would crack and moulder, and approach rapidly to decay; and if, at any future time, water or excessive rain was to overflow or to descend suddenly upon the strata thus cracked and overdried, it would have an immediate tendency to ferment and dislocate, and burst the strata into small fragments and masses of various sizes.

The learned astronomer, Mr Whiston, constantly affirms, that a Comet passed by the earth at the very time when all antiquity say the universal deluge happened; that the earth passed quite through the atmosphere and tail of that Comet, and in consequence of this near approach of the Comet, that the earth acquired thereby a great quantity of a watery vapour, which fell down in heavy rain upon the earth. This is not contradicted by other astronomers; on the contrary, the learned in general assert, that a Comet did appear at the precise time mentioned by Whiston. If this Comet approached so near the earth as Whiston says it did, besides the watery vapour which the earth would attract from it, the Comet would certainly have a mighty effect in disturbing our atmosphere, in causing excessive rains to descend from thence, and in raising the tides of the ocean to a monstrous height, which tides would overflow the land, and by their prodigious

digious weight and force would tear up the antediluvian strata, and soon break them to pieces, when mixed with the water. By this means, the shores and mural barriers of the ocean would be broken up, which would facilitate the mixing of the land and water in a chaotic state.

When once the strata began to be dislocated and broken up, either by the descent of heavy rains upon the dry and half calcined strata, or by the tides invading and overflowing the land; the fermentation and destruction of the parched strata would advance rapidly, until the solid surface of the globe was broken to pieces, and blended with the waters of the ocean in a general chaos.

I exclude from my observations all concern with central waters issuing out of the bowels of the earth, to overflow and disturb the surface. I do not know that any such waters exist; nor is there any way for me to acquire such knowledge. I have no doubt but this planet of ours has some relation and connection with all the other planets of the same system; but what degree of density and gravity, &c. in proportion to its magnitude and situation, is requisite to answer its relation to the rest, is out of my power to know; and without this knowledge, there is no ground left for me, so much as to form a probable conjecture, whether the center of the earth is solid or fluid,

light

light or heavy, dense or rare, hot or cold ; and therefore I will not meddle with the center of the earth. The superficies of this planet is exposed to my inspection and enquiries, which I will pursue, and submit my observations to the censure of the candid naturalist.

Some philosophers oppose the doctrine of an universal deluge, from the supposition of its absurdity, as they imagine. These gentlemen allege, that it reflects dishonour upon a wise and intelligent Creator, to suppose that he would make any of his works so imperfect at first, as to require an after-change or reformation. This objection may appear at first sight both plausible and strong ; however, it is not supported by the oeconomy of nature and experience.

We find nature full of change, and generally for the better. We are most sensible of these changes in animated nature, where the transformations may be properly called advances to a better state.

The sordid caterpillar of last season is now a shining butterfly, floating at pleasure in the ambient air, and sipping the nectar of every flower ; and we hope for a greater change : In short, nature is full of change or advance ; but why it should be so,—why all creatures are not made inimitably perfect and permanent at first,—is too deep a question to be solved by the wisdom and philosophy

philosophy of man. We know that it is so; but the reason of this and other inscrutable phenomena of nature, must be resolved in the wisdom and will of God.

From many of the phenomena of nature I am led to imagine, that the antediluvian earth was created a fit and proper habitation for man in his first perfect state of innocence; but when he fell from his first estate, and became a sinful man, by aspiring at independence and equality with God, he at the same time became a miserable man, subject to many more wants than formerly, and particularly such wants as are connected with the aids of society, arts and commerce; which the antediluvian earth was not so well adapted to supply as the present. The antediluvian strata were by far too hard, fine, bright and glorious, for the common uses of society. In order to throw as much light as I possibly can upon this great and difficult subject, I will select a few particulars, which seem to point out the necessity and the reality of the changes we are speaking of.

We have already treated of the quartz, shirl, and mica, and other fine grains and masses found in the composition of our strata; and have hinted that these must be fragments of some ancient strata, that is, of the antediluvian strata. We shall take

take a cursory view of the principal phenomena of some of these fragments.

1st, Talc and mica is one of the finest and most beautiful substances in the world ; and though in general it is broken exceeding small, in which state it is called mica ; yet I have seen many fragments of it much larger than any other of those I call ancient. I have, in the Highlands of Scotland, seen fragments of it up to four or five inches broad, and more than one inch in thickness ; and it is found in still greater masses in some of the Russian dominions, where they use it for window-lights, where it has acquired the name of Muscovy Glass. The stratification of the masses of talc is so exceeding fine and perfect, that it is impossible to conceive how thin the laminæ of it may be divided, without seeing it ; and I know of nothing that is more bright, smooth, shining, and pellucid, than the thin plates of fine talc.

2^d, I imagine that the larger fragments of quartz and feldtspat, which are seen in some granite rocks, or in granite gravel, from the decomposition of those rocks, may be ranked next to the talc for the size and magnitude of the masses. I have seen distinct masses of feldtspat imbedded in the granite rocks of Galloway, and other parts of Scotland, of an oblong or quadrilateral figure, up to two inches long, and more than one in breadth and thickness. These large masses always appear
of

of a finely stratified or tabulated structure; but the leaves or strata are strongly cemented together, so that these fragments are not so divisible as the talc.

3d, I suppose the diamond may come in next to the quartz, for the magnitude of its masses. I reckon that the diamond, and all the gems and precious stones, which are not of a prismatical figure, from their being chrystallized in the cavernous parts of our rocks, are fragments of the ancient strata. All those fine masses and grains which are of a stratified or tabulated structure, are certainly ancient: And the diamond is known to be, perhaps, as finely stratified as the talc itself; and there is certainly no fossil in the world that has a finer fabric, and more perfect stratification than talc. The diamond is so hard and strong, that it can only be broken by splitting or cleaving it asunder; but the laminæ or stratified plates of the diamond are so strongly and so finely cemented together, that they cannot be discerned or any way known to exist, but when force is used to break the stone. The diamond, and many other gems, are found in the potatoe form, which shews them to have been rolled in water, until the asperities and sharp angles were rubbed off; and their tabulated structure proves them to be fragments of some ancient strata. But that I be not over tedious to no purpose, I will observe here in general,

ral, that the same thing may be said of all the other fine, bright, pure, and pellucid grains and masses found in the composition of our strata, which has been said of the above-named. The brightness and beauty of their colours, the fineness, and the tabulated or stratified fabric, proves them all to be fragments of some ancient strata ; and we must acknowledge those ancient strata to be antediluvian..

Now it is remarkable, that all the gems, and most of the fine grains and small masses found in the composition of our globe, or among the debris of the decomposed superficies of our rocks, are of various bright and beautiful colours, such as red, an azure white, green, blue, yellow, &c. with various shades and tinges of these and other colours ; and it is also remarkable, that excepting talc, all these grains and masses, from the small grains of sand up to the costly diamond, are exceeding hard ; even so hard, that no tools of our tempering would be fit to pierce, or to have any impression upon rocks of them. We find in our rocks fine grains of a great variety of colours, from which we may infer, that there was a great variety of strata in the antediluvian earth ; but as these colours are very bright, and the grains very hard, we may also infer, that those strata were not very fit for the common purposes of life. They were too hard to be quarried and worked,
and

and too bright and glorious for the eye of man to behold in buildings, and other common uses of society.

These remarks upon the antediluvian strata suggest to me, that the earth was first formed a suitable habitation for such a glorious, perfect and happy creature as man in innocence; but when man sinned against God, by aspiring at equality and independence of his bountiful Creator, and Sovereign Lord, he soon experienced a fatal change. His mind was defiled with sinful and unruly passions and appetites, and his body became mortal, frail, and vulnerable. In short, man then became sinful, miserable, and wretched, exposed to sickness, pain, and a thousand woes and inconveniencies, which made the aids and accommodations of society absolutely necessary for his tolerable well-being in this world; and the Almighty did not leave him destitute, but pitied him in his low estate, and provided for his accommodation.

Although the antediluvian earth was perfectly suitable for the habitation of man, as he came from the hands of his Creator; yet it was not so suitable as the present to supply the various wants of such frail and wretched creatures as we are now; and that, when it pleased the all-wise, benevolent, and merciful Creator to pity us in that low estate, into which we had plunged our-

selves, by attempting to climb too high ; and when it pleased him to lay our help upon an Almighty Saviour, who is able to deliver us from eternal ruin, to raise us up, and restore us, even here, to virtue, dependence, and hope ; the Almighty was also pleased, in proper time, to take to pieces the fabrick of our first habitation, and to rebuild it with additional accommodations, fully adequate to the various wants and conveniences of miserable man in a social state of industry and commerce.

We know very well that the strata, and the minerals of the postdiluvian earth, are fully adequate to all the demands, and perfectly convenient for all the accommodations of society ; but we have good reason to doubt that the antediluvian strata, &c. were not so suitable for our purposes. I am confident that there was no pit-coal in the former earth ; the origin and source of which was the antediluvian timber, which we have already explained ; and coal is of such vast consequence to a flourishing state of society,—to arts, manufactures, and commerce in our part of the world, that we could make but a poor figure without it, and its consequence will increase in other countries as well as ours. We know that our gross compounded strata, and the order of their disposition, are exceedingly convenient for our quarrying and building houses, harbours, bridges, and for making

ing roads, &c. I doubt much if the hard and fine textures of the ancient strata were fit for any of these purposes. Our coarse compounded materials are very fit for high roads; but I would not wish to be obliged to travel in a sunny day upon a pavement of diamonds, talc, and rubies. None of the virgin metals we find, such as gold, silver, copper, will make a good edge, nor have they the strength and hardness of iron. Iron, which is of more intrinsic value than all the gold and gems in the universe, appears to me to be altogether a compound mineral; and that it was prepared and dispersed by the chaotic state of the deluge, all over the superficies of the globe, as we find it in such vast profusion, like the other necessary and common bounties of nature. What could we do without iron in an improved state of society, arts, and commerce? And supposing iron to have had the same quality and properties before as since the deluge, yet if it was deposited in strata among a multitude of other different strata, as hard and impenetrable as the samples which we have of them, there could not a sufficient quantity of iron be raised to answer the demands of society. I do but lightly touch these obscure, though interesting topics, and leave them to be examined and treated more amply by the intelligent naturalist, and he will find that the phenomena of nature favour my conjectures.

I observed above, that the great philosopher Moses has pointed at the manner of the formation of the primitive strata, in the significant words of the *Spirit*, or *wind of the Lord God moving upon the face of the waters*, which denotes their being put in a gently flowing motion, whereby the fine and beautiful strata of the antediluvian earth were formed ; and I imagine, that most of those strata were thin, but very regular ; and this supposition is founded upon the inconceivable fineness of the materials, or particles of which those strata were composed ; and if those strata were generally thin and hard, they were the more subject to be cracked by excessive drought, and they would be the easier burst asunder, broken to pieces, and taken up in the waters of the deluge.

The same great philosopher uses a different language, or form of words, when he points at the destruction of the ancient strata, and the formation of the present superficies of the earth. He says concerning this subject, that “ the fountains of the great deep were broken up,” by which I understand the dissevering, and breaking to pieces the superficies of the ancient strata, which were the only mural boundaries of the ocean, for there was but little or no sand then ; sand being evidently the remains of the primitive strata broken to pieces, and ground small by attrition
in

in the chaotic tides. When the primæval strata were broken up, Moses says, that “ the waters prevailed, and increased exceedingly upon the face of the earth.” I am very much inclined to give credit to Whiston’s account of a comet’s approaching and passing near the earth at the time of the deluge. It is generally agreed, that a comet did appear at the precise time mentioned by Whiston. If that comet came as near the earth as he says ; and if the earth passed quite through the atmosphere and tail of that comet, no doubt, it would occasion the catastrophe of an universal deluge. Upon that supposition, it is impossible for us to imagine, with any respect to the nature of things, that such an event would not happen. The earth, passing through the atmosphere of the comet, would, undoubtedly, attract to itself a great quantity of that atmosphere, which would fall down in rain upon the earth. As there had been no rain before the deluge, we may suppose that our atmosphere was by that time plentifully charged with watery vapour ; now, the attraction of a comet passing so near the earth, would raise a terrible commotion in our atmosphere, which alone was a sufficient cause of prodigious quantities of rain falling upon the earth ; which rain, when joined by the high tides, which must be raised by the attraction of the comet, were sufficiently powerful causes

causes of an universal deluge. Attraction is known and acknowledged to be an essential property of bodies; and although they mutually attract one another, yet the greater the body, and the more matter it contains, the powers of attraction will be proportionally great. Whiston and other astronomers assure us, that the comet which passed by the earth at the time of the deluge, is considerably less than the earth; from whence we may conclude, that the earth had a greater chance of robbing so small a comet of part of its atmosphere, than of being robbed by it. Such a comet passing so near our earth, would certainly, by its powers of attraction, greatly disturb our atmosphere, and raise the tides of our ocean to such a monstrous height, as to overflow the land; and when the land was overflowed by such high and weighty tides, the weight and force of such tides would certainly tear up, and break to pieces, the primæval strata.

Philosophers may be allowed to form conjectures concerning the use and intention of all natural bodies; and to know the real use of a thing, and the intentions of the Deity in producing it, is among the most profitable and most comfortable attainments in natural knowledge; and we rejoice in our participation of such knowledge. What if the use of comets should be to carry
such

such supplies to the planets as may be necessary and useful, to bring about revolutions, changes, or advances, by fire or water? The decay, the waste, and the destruction of one body, animal or vegetable, &c. in our world, is made use of for the well-being of another: But this mystery is too deep for me; and therefore I will content myself with the bare hint.

We have nothing in nature capable of assisting the imagination to conceive proper notions of such monstrous tides, as a chaotic state of the terraqueous globe would be raised to; any thing that we have seen, or can see, of floods and inundations, being too trifling to assist our ideas. Mr Fergusson's chapter upon Tides is perhaps the best illustration of this subject, and the best aid we can get to assist us in forming proper ideas of those tides.

When once the tides were by any means raised so high as to invade and overflow the land to a great depth, there is no room to doubt, that the violent rushing forward from east to west, of such a prodigious weight and depth of water, would soon tear up and destroy the solid superficies of the globe. I have had a good deal of experience and observation in a practical branch of mining called *hushing*; which is frequently practised in making trials for mineral ores upon sloping grounds, and sometimes for hushing or scouring

scouring the rubbish out of old works, in order to get what ore has been left in the rubbish. Hushing is performed by making a hush-dam or reservoir, with a sluice as high up as water is to be had; and by cutting a trench in a right or a diagonal line down the slope, and letting out the water to scour and deepen the trench, or hush-gutter down to the bare rock, in order to make discoveries. When this operation is so far completed, that we have washed or hushed away every thing off the face of the rock within the gutter, it cannot be imagined, nor if told would it be believed without seeing, how the solid surface of the rock is torn up and carried down the hush-gutter by the weight and force of the water; and if two or three feet deep of water, blended with stones and rubbish, can do so much, what may we not suppose twenty or thirty thousand feet deep capable of doing.

We have, perchance, seen a small branch of a river break out of its channel in a flood, and take a new course, and then we have seen what havoc that small current has made upon the face of the ground.

But every thing that we can see or think of is so very diminutive and trifling, as not to be suited to raise our ideas to proper conceptions of the amazing weight and force of tides rising several miles in height, and rushing forward in the
full

full force of such a height. When the waters of the deluge had so far “prevailed” as to break up the primæval strata, and to blend them in those high tides which overflowed all the land; it is pretty easy to conceive, that the prodigious and unequal agitations of such tides, in their periodical motions westward, would be fully adequate to grind down the fragments of those strata by attrition, into such grains and particles as we find in the composition of our strata.

When we reflect upon such a chaos,—a world of water and broken rocks, blended together in monstrous agitation and forward motion, and all the stones continually grinding one another, by rolling and attrition, in the violent progressive motions of such tides of the chaotic mass; it is a wonder that any grains and fragments are left sufficiently distinguishable to give us any notion of their being primæval strata, and that they are such, I have clearly proved before.

When the remains of the primæval strata had been rolled about long enough in the agitations of the chaotic tides, to prepare the debris of them to be fit for being formed in such strata, as would be most suitable and convenient for the various purposes of the post-diluvian earth, the most violent agitations of the chaos began then to abate, and the superficies of the earth began to be formed a-fresh, of the various coarse grains

which were ground down and blended together in the waters.

I hinted before, that part of the solid surface of our globe, such as the granite rocks, composed of large grains and masses, was formed by subsidence in deep water, which I suppose to be done when those high tides were in some degree of rest, about the height of the tides; and that the more regularly stratified parts were formed by water in motion, when the tides were moving westward after the Sun and Moon.

Behold in the granite and porphyry rocks, a clear demonstration of the truth of my natural history of the superficies of the globe. Some of the granite rocks of Lochaber in the Highlands of Scotland, and many others which I have seen, are wholly composed of large grains of exceeding fine stones of various bright and beautiful colours, cemented with the same, which rocks were described above. Now, these large grains and small masses of the primæval strata, were too heavy and bulky for floating long in the chaotic state of the deluge; and therefore, this gravel-like matter subsided first, immediately when the rage and violence of the first chaotic storms began to abate, and this coarse or large grained matter subsided before it was any way debased or mixed with heterogeneous matter not so pure and pellucid. Some of the fine granite and porphyry

phyry rocks, such as that of Bineves in Lochaber, are perfectly fine and pure throughout, being wholly composed of the debris of finely coloured pure and pellucid strata of the antediluvian earth, cemented by a fine sand of the same. Most of the huge and misshapen granite rocks of the world are of this description, in respect to the large size of their grains, though they are not all composed of equally beautiful materials. The Lochaber granite, and many others which I have seen, would perhaps be the most beautiful stones in the world when polished.

The great naturalist Moses points at the formation of our strata, after the deluge was past the height, in very few, but expressive words: He tells us, that this great operation was performed by the agency and motions of the returning reiterated tides. After informing us that "the rain from Heaven was restrained," he says, that "the waters returned from off the earth continually;" or that "the waters were continually going and returning:" which words clearly point at the ebbing and flowing of the tides, or, as he expresses it, the going and returning of the high tides in the chaotic state of the terraqueous globe: And a little forward he says, in his very brief and expressive narrative, that "the waters decreased continually;" or that "they were continually going and decreasing." Genesis 8.

The

The best mode of expression is in the margin of the London Baskett's Bible of 1741, and some others. Moses plainly points out to us the decreasing of the height of those tides, as the matter which composed our rocks and strata was separated from the waters of the ocean. I know very well that it is very unfashionable to make mention of Moses, or any way to allude to his writings in a work of this nature; but if Moses's writings and the book of nature agree and correspond together, I incline to do him justice. I have not yet met with any thing that contradicts him, in all my researches into the Mineral Kingdom; and if Moses and Nature speak the same language, why should I reject his account of these matters? I have attentively examined these subjects, in a sedulous persevering search of truth, with an impartial eye, and I find Moses and Nature agree; and whenever philosophers will take the trouble to compare my imperfect writings with the perfect originals in the book of nature, they will then be fully convinced of the truth of Moses's brief, but perfect narrative.

We may add to the above particulars, from the Mineral Kingdom, a very powerful argument in favour of an universal deluge, deduced from the distribution of the various kinds of animals over the different parts of the earth; and if this
matter

matter is examined impartially, it may be considered as a decisive proof of the question.

We know that Noah's Ark grounded upon Ararat, one of the highest mountains of Armenia in Asia; from whence, the inhabitants of the post-diluvian earth, man and beast, were gradually increased and spread over the whole face of the earth.

When Columbus discovered America, in 1492 of the Christian æra, there was neither elephant, rhinoceros, camel, lion, ox, nor horse in the new world, nor any other tame nor wild animal that is peculiar to the torrid zone, and to the other warm climates of the Old Continent.

Most or all the quadrupeds found in America, were such as are found in cold climates, or indifferently, either in cold or warm climates.

This remark merits the consideration of natural philosophers. I know very well, that our learned philosophers, who either deny or doubt the reality of an universal deluge, are very well informed of the comparatively small number of quadrupeds found in America; yet, perhaps, they have not considered this well known fact, as having any relation or connection with the proofs of the deluge. But however that may be, I am bold to assert, that this historical fact is a clear proof of that great catastrophe.

The

The natural cause of this singular phenomenon deserves to be investigated.

I have been long persuaded, that the continent of America is joined to the north-east of Asia; and the researches of the justly celebrated Captain Cook, in his last voyage upon the west, the north-west, and the north-east coasts of America, has cleared up this geographical difficulty, and decided the question beyond a doubt in favour of my opinion.

I am further persuaded, that America was at first peopled by land from the north-east of Asia, and that the native Americans derived their remote origin from some of the eastern Tartars of the cold regions to the north of Corea, or of the northern parts of Russian Tartary.

The copper colour, the thin beards, and the general character and manner of living of the Northern Tartars, and the Americans, favours this hypothesis. The emigration of the Tartars to America must have happened in a very early period, before the frozen snows of the northern regions were accumulated to such a degree, as to block up the passage between the two continents. At present, there is no passage between them by land, on account of the mountains of snow, which have been accumulating for four thousand years. However, this accumulation of snow would not begin immediately after the flood. It is natural

to

to suppose, that the frost and snow of winter would thaw and melt away in summer in the northern regions for a considerable time, as it does now in more temperate climates. Perhaps, the frost and snow of the valleys might continue to thaw and melt away for several ages before the mountains of ice and frozen snow began to accumulate over the whole face of the immense regions of the north ; though the snow is now heaped up to perhaps many miles of perpendicular depth over the face of the valleys, as well as the mountains. The mountains of ice and frozen snow would begin by slow degrees. At first, some little snow would remain upon the highest mountains all summer, which would increase by degrees, untill it began to remain over summer upon the lowest hills ; and this increased quantity of snow would increase the rigours of the seasons and climate, which would become more and more cold and stormy every year ; and at last, a severe season would pour down such a vast quantity of snow, that the next summer's sun could not melt it off the valleys ; and then the foundation was laid of the present mountains of ice and snow ; and more is piled up and built upon this foundation every year. The quadrupeds found in America, when Columbus discovered that continent, would proceed there from the Old Continent long before the rigours of the climate would
 increase

increase to this extremity of cold. Wild beasts love to roam at pleasure, excepting when they are pursued by their enemies, or shun the resorts of men, and the haunts of more powerful ravenous animals. Beasts, as well as men, make war upon, and destroy one another. The harmless, the timid, and the weak of the brute creation, fly from, and shun the cruel, the strong, and ferocious. The wild beasts of prey, and such as were not immediately domesticated or tamed for use, would be turned loose in the country of Armenia, to shift for themselves as soon after the flood as the earth was in proper condition to produce abundance of fruits, roots, and herbage for their sustenance.

Armenia being situated in about 40 degrees of north latitude, such beasts as delight in cold climates would soon spread to the furthest northern latitudes; and the weak and timid would advance faster than natural inclination prompted them, being obliged to flee from their numerous enemies. These natural causes, and natural propensities, would bring a variety of quadrupeds into North America, before the whole face of the northern regions were covered over with eternal snow: And it may be observed, no quadrupeds were found in America when Columbus landed there, but such as can live a considerable time in the woods. Captain Cook found the coasts of the
most

most northern parts of America covered with wood ; and no doubt, the inland parts were woody before the mountains of frozen snow began to accumulate. Many of the quadrupeds would live in the northern woods for some winters, before they advanced further south, and they would be subsisted, some by browsing, and some by preying upon others. But most of them would advance rapidly towards the south ; the timid being propelled by their enemies, and the carnivorous pursuing their prey. The bear, and other ferocious animals of the cold climates were found in America when first discovered ; but there was neither lion nor tiger, nor any other of the fierce inhabitants of warm climates, excepting one species of panther, or some other kind of the spotted tribes. Some of the earliest Spaniards of America might introduce a breed of these fierce animals from Asia, with a view of training them for the chase, to hunt the deer, and other harmless American animals ; and these might break loose, run wild, and soon fill the woods with their progeny. The cruel character of the Spaniards at the period of their first conquest of Peru, fully justifies such a conjecture : And the hunting of leopards is very common in Asia.

There is another way of accounting rationally for the appearance of this species of leopard in

America. A pair of them might pursue the lama and pacos northward, in a very early period, and never give over the chase, until those harmless creatures settled among the precipices and snows of the Cordilleras, where their spotted enemies could not subsist for cold, nor could they run as fast as the lama among the rocks and stones of those mountains. There are none of these camel-sheep in any part of the Old Continent that I know of. In their wild state, among the Cordilleras and Andes, these harmless, useful creatures are so vigorous, lively and fleet, that they bid defiance to the chase of every other animal whatsoever. They can only be taken or killed by stratagem, even when they come down to the lower skirts of the mountains. Nothing can come near them when they take the alarm and begin to run off.

The lama and the pacos are only found in South America, where they have a tame breed of them; and they are harmless, useful creatures, but incomparably more slow and phlegmatic than in the wild state. In that state, where they enjoy perfect freedom, and a choice of food and climate, these creatures are exceedingly active and strong; they delight in the regions of snow, among the coldest mountains of South America; and are said to be found among the range of these mountains, as far south as Patagonia.

gonia. In the wild state, the lama is called guanaco, and the pacos, which is the smaller of the two species, or varieties of American sheep, is, in its wild state, called vicuna. It is said, that the vicunas are still fonder of the summits of mountains, and of the coldest regions of ice and snow, than the lama.

Now, the lama and pacos being only found in America, and not in any part of the Old Continent, and their delighting in the highest, and consequently the coldest ranges of mountains in the world, favours my conjecture, that these harmless creatures would wander from Armenia towards the north ; and that they might be chased by the American leopard, in a very early age of the world, as far as the Cordilleras, before they found a place of perfect safety from this ferocious enemy. The lama and pacos not yielding such fine fleeces, and perhaps not such fine flesh as our sheep ; and being more capable of securing their own safety among the roughness and cold of the highest mountains, would be turned loose by Noah and his sons. The sheep was more worthy of their care, and they had more need of it, being, comparatively, but slow of foot, timid, and defenceless. And moreover, the first men had no inducement to incumber themselves with the care of any other animals of this kind, as the

sheep

sheep would afford them abundance of the finest fleeces, and of the best and most wholesome animal food.

War is as natural to the savage state of mankind, as to the civilised. It is rather more incident to the savage, hunting being a sort of proper education for training up the savage for war; and the causes or motives of their wars are as common and as trifling, if not still more trivial and frivolous.

The concerns, the privileges, and pretended laws of the chase, breed as many quarrels among the savage, as the disputes about territory and the affairs of commerce among the civilized nations.

The first emigration of the Americans from the Old Continent, might have happened in consequence of the loss of a battle,—the loss of their domestic animals, or of their grazing and hunting grounds, which the conquerors would take possession of. In this case, the conquered would be obliged to fly northward, to conceal themselves in the woods; and if reduced to few in number, they durst not return for fear of being all massacred.

The laws of war among the Americans, to this hour, is implacable revenge and destruction; not to subdue for the honour and advantages of the victory, but if possible, to murder and exterminate the whole race of their enemies. This kindred

dred feature of ancient Tartarian barbarity, has been sufficiently exemplified, both in the old and in the new world, to prove the kindred and similarity of character and manners of the Tartars of both continents. Jenghiz-khan in the old, and the Iroquois in the new world, are well authenticated proofs of the justice and propriety of this observation. The celebrated barbarian Jenghiz-khan murdered millions without cause, or hardly any pretence of provocation ; and if he and his blood-hounds had lived long enough, they would have exterminated most of the human race out of the Old Continent ; and his kindred in the new always shewed as good will, only they wanted equal power.

If we are rather inclined to suppose that the first emigration of the remote ancestors of the Americans was voluntary, and not the result of the fate of war, or other absolute necessity, this will make very little alteration of future circumstances. In this case, the whole horde or hordes would remove with all their bestial, and other effects (a short inventory), in the same manner as the hordes of Tartars have always removed from place to place, in all ages down to this very time ; yet, even upon this supposition, there could be no more domestic animals in America, than the Europeans found there in the fifteenth century.

century. Supposing they carried numbers and variety with them, they must all die by the way of cold and hunger, in the inclement and barren regions of the north, which Captain Cook found to be exceedingly extensive. It is natural to suppose that the emigrants themselves would have great and insufferable hardships to encounter in passing through these dreary, extensive, and inhospitable regions, and that they would be reduced to few in number, and to a miserable condition, before they arrived at, and settled in more temperate and fruitful climates. In this journey, and in these circumstances, their savage state was very much in their favour, being accustomed to live hardily, and to kill and subsist upon wild beasts; they would find some of these by the way, which would often supply their wants; and as the inland countries might then be shut up with snow, it is probable that they would travel by the west coast, in which route they would find abundance of shell-fish in most places. It is very probable that the sea-coast was the only open passage. Captain Cook found every mark and appearance of a great and extensive continent in the most north-western parts of America. The river Turnagain, which falls into the ocean about the latitude sixty north, is one of the largest rivers in the world; the shores of which river, and of the sea thereabout,

was

was covered with snow in summer down to the very beach ; and it is very well known, that such rivers always derive their sources from great and extensive continents. But notwithstanding the rigours and the eternal snows, Captain Cook found these dreary regions inhabited by a race of swarthy people of low stature, the effects of the climate ; and it was very evident, that the inhabitants must depend entirely upon fishing and hunting all the year round, as nothing could be got from a land eternally covered with snow.

This historical fact lately discovered suggests to us, that only some of the first emigrants, or of their immediate posterity, pushed forward to the temperate and warm climates of America, and that some of them remained by the way in the most dismal regions of the north, where they found a wretched, but sure subsistence, by fishing and hunting, which became agreeable by custom, and a sense of the tranquility of their situation, far from the danger and disturbance of powerful neighbours. The powerful effects of long habit has brought the Esquimaux to prefer the eternal snows and rough seas of Labrador to all the rest of the world. But although the Tartarian emigrants could be supported by the sea, and by the woods, in the long and tedious passage by the north-west coast of America, until they arrived in warmer climates and an open country ; yet the
the

the domestic and useful animals of the old continent must all perish by the way, and very soon too, there being nothing in the world for them to eat, during the long winters of the north, in a passage of several thousand miles. The west and north-west of America, from latitude 44. to the junction of the American and Asiatic continents, is said to be three thousand seven hundred miles, in the account of Captain Cook's last voyage. We are not however to imagine, that all this great length of coast is constantly covered with snow; but we may confidently assert, that at least one third of it is perpetually covered from generation to generation; and we may as confidently assert, that one thirtieth part of it, when totally covered with snow, is sufficient to kill all the domestic animals of the Old Continent, where they could get neither provender nor shelter from the rigours of the climate. The whole of this immense distance would be covered with a great depth of snow, through the whole length of every winter; and the most of the ground in the northern climates consists of boggy morasses, and of woodland, where man might find game to kill; but our useful animals would find nothing to eat, nor could they find any shelter; and of consequence, none of them could be preserved alive; and none of them were found in America when the Europeans landed there in
the

the fifteenth century. And it may be inferred,— I might say proved, from this very circumstance, that America was at first peopled by the north; and that the first inhabitants walked there by land. Had they gone there by sea, they would have carried some of the domestic animals of their own country with them; but none of ours were found in all America.

It may be objected to this, that it is not probable the native Americans derived their origin from the Tartars. The Tartars have had the art and custom of taming animals in all ages, and of making use of them, at least, for carrying burdens, and for supplying milk and flesh for their subsistence. The Americans, on the contrary, had not the art of taming animals; nor had they any knowledge of their domestic uses when Columbus discovered their country; and therefore, it may be inferred, that the original Americans must have arrived there from some island which had not the knowledge and use of domestic animals. In answer to this objection, I would ask, how they could tame and use what they had not, and what was not in their power to have? There was no domestic animal of the Old Continent in all America when Columbus landed there; of consequence, it was impossible for the natives to tame and domesticate what they had not. The only native animals in all America, capable of be-

ing domesticated, and made considerably useful, were the lama and pacos ; and these were tamed and used by the Peruvians for carrying burdens, and for food and cloathing. However, I am of opinion, that the celebrated founder of their Empire, and their wise law-giver Manco Capac, learned them to tame and make use of these animals, as well as the other arts and civil institutions which he established among them.

The wise founder of the Peruvian Empire would soon want the fleeces of the lama and pacos to cloath his own family ; and therefore, he would procure young ones and tame them, and their great size and strength would suggest to him the thought and the experiment of using them for burdens, in the hilly country of Peru, where they had no other animal fit for such an use ; and when they became plenty, they would try their flesh, and find it good and wholesome food.

Whether the original Americans were at first driven into the deserts of the north by savage wars, or that they voluntarily emigrated, or gradually moved and advanced northward, they would be very soon deprived of all their domestic and useful animals, either by the war of their brethren or of the elements. They could not survive one winter without any manner of shelter, or of provender, in the dreadful rigours of the
the

the north. The emigrants themselves would be a long time by the way, perhaps so long, that the men and women born in Tartary would be all extinct before they arrived in the temperate and warmer climates; of course, they must have lost all knowledge of the domestic and useful animals of the old world, as well as their use, and the art of taming them; and it was impossible for them to recover this knowledge and art, when they had none of these cattle. The lama and pacos were only found among the lofty mountains of South America, and it would hardly occur to the barbarous savages of those regions, to domesticate them before Manco or Madoc arrived among them. They were not domesticated themselves till then. We observed before, that the emigrants must have suffered great and intolerable hardships by the way, during a very considerable length of time; and nothing in the world has a greater tendency, and more powerful effects in reducing mankind to a state of absolute ignorance and rusticity, than long and insufferable hardships, even supposing them to have been derived from a civilized origin; but we have shewed, that the remote origin of the Americans was the Tartars of north-east Asia, who have always been a savage, barbarous, and ferocious banditti; and these reflections may sufficiently account for the savage barbarity of
the

the Americans, and for their extreme ignorance of, and aversion to the manners and customs of the old world, when they were first discovered by Columbus ; and the case is not yet much altered. Where they are not under the immediate force of some powerful impulse or restraint, they are not yet more placable or civilized, nor have they altered their customs or manners ; and the same may be said of their ancestors the Tartars. The Tartars have continued in a savage state of barbarity for more than four thousand years past, though surrounded by civilized nations, and possessing immense regions of the best lands and climates in the world, situated in the temperate zone, which they neither plough nor dig ; no wonder, then, if their brethren the Americans are so attached to the savage state,—should have forgot their origin, and were found so ignorant and averse to our manners and customs.

Let us now consider the force and import of these facts and reasonings, as far as they are connected with the proofs of the universal deluge.

The records, the traditions, and belief of all antiquity, leave no room for us to doubt, that Noah's Ark grounded upon Mount Ararat in Armenia, which is situated as near the center of the Old Continent as can be imagined ; a proper center from whence to distribute all the future

ture inhabitants of the earth, man and beast.— America is connected with the Old Continent by the extremities of the north; but the Ark, with all the land animals, grounded in Armenia, where they must propagate, and from whence they must spread abroad and replenish the earth. From this arrangement of things, and of situation and climate, only a very few kinds of the large, the noble, and the useful animals, could reach America, and these few only such as could bear the rigours of the north, or that could pass quite through the most inhospitable climate in a short space of time during the summer season; or such as could defend themselves against the effects of the extreme coldness of the climate, and find subsistence by the way to support them during a long peregrination.

If we take but a cursory view of the constitutions of the larger quadrupeds, we shall be convinced, that according to these observations, not many of them could reach America. Among the harmless and domestic animals, the elephant, camel, bull, horse, ass, sheep, swine, &c. could not bear the cold and rigours of the north; nor could they find proper and necessary food and shelter in passing through it to warmer climates. Among the large, savage, and ferocious animals, the lion, rhinoceros, tiger, &c. could not bear the

the cold of the north, nor could they find shelter from the rigours of the climate and seasons.

Let us now take a view of the natural history of America, when Columbus discovered that great continent in the fifteenth century; and in this view, we shall not find so much as one of the above-named animals among all the quadrupeds of the new world in that æra. If we divide the larger kinds of the land animals which were natives of America when first discovered, into the harmless and the savage, we shall find but a few species of the former, and not a long list of the latter, over the whole bounds of that immense continent. Among those of the former character, must be reckoned the lama and the pacos, and several species of deer. This is but a small number and variety; but however small it is, I do not know that there was any other large animal of this character in all America when first discovered; and it was physically impossible that there should be any more, unless they had been carried there by sea, as the European nations have done since that period. The lama and pacos delight in the summits and frozen snows of the highest mountains; and therefore, from a consideration of the nature of things, we might expect to find these in the New Continent, because these would not feel the rigours of the north; they could secure themselves from
their

their enemies in the safe retreats of rocky precipices, and such places as are inaccessible to all other large animals; and they could subsist in winter upon the branches of trees and shrubs, without water; and these are found in America, and in their natural state, among the Cordilleras and the Andes, the highest ranges of mountains in the world, which are places suitable to their constitutions, and for their safety. Various species of the cervi, or deer kinds, are almost the only large harmless animals found in the new world, besides the lama and pacos. All the deer kinds can suffer cold, being defended by thick furs, and they can subsist in winter upon the branches and the bark of trees and shrubs; and therefore, it was natural to look for these in America, and they were found there. Among this small number, the lama and pacos were perhaps the only animals which the Americans could domesticate and bring to any considerable degree of utility, and these were tamed, and used for burdens, food, and cloathing. The native Americans killed the wild deer for food, and used their skins for cloathing; and there is generally no further use made of these animals in the Old Continent, excepting that the Laplanders domesticate the rein deer, train them to draw sledges upon the ice and snow, and use their milk and flesh as we do the cow's.

It

It is said that rein deers are found in the northern parts of America, but whether they are tamed and domesticated there or not, I cannot tell.

The large savage ferocious animals of America are not much more numerous than the useful and harmless. Various species of bears may be reckoned the principal of these for strength and magnitude. Bears are common inhabitants of the most northern regions of both continents; and they agree so well with a cold climate, that they frequently burrow beneath the snow in winter; and therefore, it is very natural to find these animals in America. Among the ferocious animals of America, the next to the bear in size and strength, is a species of leopard or panther. I observed before, that probably some Spaniard introduced a breed of these, with a view of hunting deers and other large animals with them; which might break loose as soon as landed, and then they would soon multiply.

The cold regions of the north is not perfectly natural to the constitution of this savage animal; but as he is carnivorous, he might pursue his prey far to the north in an early age, and when he was there, he need not take up much time in passing through to warmer climates.

If we suppose that a number, or a pair of these, followed the lama and pacos northward, until they

they arrived in America, and that the one fort never gave up the pursuit, nor the others their fears, till the lamas gained the summits of the Cordilleras, where they could live in perfect safety, we may then account for our finding these camel-sheep, and a species of leopard in the New Continent, and for our finding none of this kind of sheep in the old. The lama and pacos either went northward of their own accord, or were pursued in an early age, before they had time to stock the mountains of Asia, where the lion, tiger, and all their enemies were ready to devour them. But after all our reasoning about the American leopard, it is very probable that he was introduced by the Spaniards. South America is now terribly infested with immense multitudes of wild dogs, which are extremely ferocious, though it is certain there was not one dog in the whole continent when first discovered by Columbus. The whole aim and pursuit of the first Spaniards in America was gold, savage pleasures, and the destruction of the defenceless natives. They were so cruel, barbarous, and regardless, that we need not wonder at their introducing any future evil; and it is now extremely difficult, perhaps impossible, to ascertain the civil and natural history of Spanish America, when first invaded and destroyed by these cruel barbarians.

The wolf, I suppose, is the third American savage animal for size and strength. But the wolf dwells among the Alpine snows of all countries, and he is so ravenous, that he will pursue his prey into any country or climate ; and therefore, it is natural to find them in America.

There is also a great variety of monkeys in America, which generally are not carnivorous, though many of them are remarkably ferocious, and the mildest of them delight in mischief. The simia, or monkey race, are very widely spread in both continents ; they delight in woodland countries, but they are found much farther north in America than in the Old Continent.

With respect to the fox and the other numerous races of the furry quadrupeds, the north is their native climate ; and therefore, we need not take any further notice of them.

These facts are remarkably singular and striking, and not easily accounted for upon any other hypothesis than that of the universal deluge. But if we allow, that Noah's Ark, with all the land animals, rested upon Ararat, near the center of the Old Continent, every difficulty is then removed out of the way, and the ancient history of America is easily understood. Upon this supposition, the extreme ignorance and savage state of the Americans becomes natural and self-explained.

The

The Tartars, a savage and barbarous people, from the beginning have always inhabited the vicinity of Armenia in the Old Continent ; and it was natural for such savages to penetrate the woodland countries of the north, and proceed to America, and there they were found, with very little alteration in their personal appearance, and still less in their customs, manners, and general character. They are to this day the very same people in both continents, without any material change or alteration, in such a vast length of time and distance.

Every thing becomes plain and natural when taken in this light. If the Ark, with all the land animals, rested in the Old Continent, there could not be many of the large animals in America, unless they had been carried there by sea ; because they could not bear the rigours of the north, nor subsist among the northern snows ; and accordingly, no large quadrupeds were found there, but such as can bear the cold of northern regions. Neither elephant nor camel, horse nor cow, lion nor tiger, were found in America when Columbus first landed there. All the quadrupeds which are found in the cold climates of the Old Continent were also found in America, and no others ; and this proves clearly, that the Old Continent is the original seat of all the land animals ; and it also proves, that the first men went

to

to America by land. Had they gone there by sea, they would have carried some of the useful and domestic animals of the Old Continent with them.

In short, every thing that comes under our consideration relating to this subject in both continents, mutually prove and illustrate one another.

I might here produce the evidence of ancient history in favour of the universal deluge, to corroborate and confirm what I have advanced about the distribution of the larger quadrupeds in both continents, as almost all lettered nations have recorded that event, either as an historical fact, or as a generally received tradition; especially the Jews, Egyptians, Babylonians, Greeks, and Romans; and some of the ancient writers upon this subject agree with Moses in the principal particulars recorded in the book of Genesis concerning the deluge; only their account is not so distinct, judicious, and consistent, as that of Moses, whose narrative is perfect, though concise. But I have neither letters, abilities, nor skill, for historical disquisitions; and therefore, I will stick to my own province, the Mineral Kingdom, where my labours may be useful, and will leave the historical part to some learned philosopher, who shall be convinced of the truth of my propositions, and of the integrity of my intentions; and from these convictions,

convictions, shall resolve to compleat what I have begun. Some good philosopher may hereafter think it worth his while to explain and polish my imperfect work, and to add the evidence of ancient history to confirm and illustrate a work of so much importance to the learned world.

A brief recapitulation of the subjects treated of in the former pages, may be of use to bring the principal particulars under one comprehensive view, in order to impress a general idea of the several facts upon the memory.

I. I have taken a general view of the prevailing strata of Great Britain; which may be considered as an epitome of the whole solid surface of our globe; and I have observed, that some of these are stratified, and that some of them are not, and the different degrees of stratification are pointed out with precision; and the facts and descriptions in natural history treated of under this head, will make gentlemen better acquainted with the fossil part of their estates and country than they were before.

2. I have given the natural history of the stratification of the superficies of the globe in a full and particular manner; and of the bearing, slope, and continuity of regular strata, and also of the fissures,

fissures, chasms, and other interruptions of the regularity of the strata ; all of which point out and prove the agency of water in motion, from which we are obliged to infer, that the solid surface of our globe was formed by the revolutions and various motions of returning tides.

3. I have examined part of Count Buffon's theory of the earth, and compared it with the real structure of the surface of our globe ; and it will appear to the intelligent and candid reader, that the great French naturalist was extremely deficient in the knowledge of this part of his subject.

4. I have treated of the natural history of mountains, and of their glens and excavations. I have thoroughly examined their interior and exterior phenomena ; and when the intelligent philosopher peruses the history of mountains, my observations upon this difficult, but sublime subject, will prove clear, convincing, and satisfactory.

5. I have looked into the interior quality and substance of many of our rocks and strata ; and I find that they are compound bodies, containing a great number of ingredients or component parts, of various qualities and colours, distinguishable

guishable from one another ; and I observe, that the different articles found in the composition of our strata have each of them a distinct appearance and quality, and a regular form and structure of their own, independent of their situation, connection, and relation to our rocks and strata : Such, for instance, are the fragments of talc, and others, which are found, and easily distinguished, in the composition of many of our rocks ; and besides the larger masses, which may justly be called fragments, many of our strata are composed of smaller, but visible grains, of different sizes, and of various colours ; but they all agree in this particular, that each of them is a distinct and a real stone, apparently homogeneous, and of a remarkably fine and uniform texture ; but it is abundantly evident, that we have no rocks nor strata in the superficies of the present earth, of the same quality and texture, from whence these grains and fragments might have derived their origin.

All our rocks are compound bodies, in which we can distinguish a variety of different parts ; on the contrary, each of these fragments appear fine, pure, and homogeneous, of an uniform texture, and some of them regularly stratified, as the talc, &c. and therefore, we are obliged to conclude, that these are all fragments and remains of antediluvian strata, which have been
broken

broken to pieces, and agitated in the tides of the universal deluge, before they were lodged in our strata.

6. I have taken a cursory view of fossil shells, fossil plants, fossil bones, and other remains of the animal and vegetable kingdoms, which are found in the composition of our rocks and strata; but as this part of my subject is generally well understood, and has been treated at large by others, I have only briefly glanced at this part of natural history, merely to shew its coincidence and agreement with the other parts of my subject. I have selected some particular strata for examination, such as the strata of coal and of ironstone; the origin, situation, quality, and structure of which, I have pointed out and described; and from the consideration of these several particulars, and of the whole phenomena of the superficies of the earth, above ground and below, I am obliged to conclude, that there has been an universal deluge; but from many of these phenomena of nature, which I have carefully investigated; I am also obliged to conclude, that this deluge differed in some essential particulars from what has been imagined and recorded by former writers upon the subject. The deluge was not brought about by producing a quantity of water, sufficient to cover the earth round about, to the depth of several

ral miles, so as to overflow the summits of the highest mountains, which appears to me impossible, without a miracle, if we allow those mountains to stand firm and remain as they now are. The universal deluge was brought on and accomplished by the concurring agency of a number of second causes ; all of which were prepared and ripened in the ordinary course of nature. From there being no rain in the antediluvian earth, the superficies of the strata gradually lost their cohesion, and approached to decay, for want of natural and necessary moisture. An immense quantity of water was accumulated in the regions of the atmosphere, by constant evaporation from the ocean and lakes, without any returns or diminution by heavy rains, during the space of near two thousand years ; but when the rain began, it continued pouring down constantly for the space of six weeks, if not six months. When this constant heavy rain poured down upon the over-dried and half calcined strata, the sudden access of such abundance of water naturally produced an ebullition and ferment, whereby the dislocation and destruction of the solid surface of the earth was soon completed ; and by this means, the rocky shores, which were then the only mural bounds of the ocean, were decomposed, broken to pieces, and mixed with the waters of the ocean, and of the rain. When the bound-

daries of the ocean were thus broken to pieces, and mixed with the waters into a sort of chaos, the fluid surface was soon greatly enlarged, and thereby a much greater surface of attraction was exposed to the influence of the Sun and Moon, and of consequence, the tides would be proportionally raised; and this natural cause and means, when joined with the constant heavy rains, and the dissolution of the superficies of the strata, would, when all united, soon overflow and destroy the whole solid surface of the globe, and produce an universal chaos or deluge.

Whether this great event and conclusion of the former earth was wholly accomplished by the maturation and concurrence of the ordinary second causes alone, or if there was super-added some extraordinary and extraneous cause, to hasten and augment the operation and effects of the ordinary natural causes, I will not determine. Whiston says, that "a comet cutting the plane of the ecliptic, in its descent towards its perihelion, on the first day of the deluge, passed before the body of our earth;" and the same learned astronomer tells us, that this comet came so near to our globe, that the earth passed quite through the atmosphere and tail of that comet, whereby the earth attracted and acquired from the comet a great quantity of watery vapour, which fell down in rain upon the earth. He further tells

us,

us, that this comet was about six times as big as the Moon, and that it came so near to our globe, as, by its attraction, to raise the diluvian tides to the extraordinary height of about thirty miles perpendicular. I observed before, that Whiston has not been contradicted, but rather confirmed in these calculations, as other astronomers own the appearance of such a comet at the precise time mentioned by him; but as I am no judge of these matters, I will not insist upon this concurring cause of the deluge. All, therefore, that I will say concerning the comet is this: If such a comet came so near the earth at such a time, the necessary consequence must be, that its approach would greatly hasten and augment the other natural causes of the deluge; which causes we have adduced from the natural constitution of things before the flood; at the same time, the approach and effects of a comet do not appear to me absolutely necessary to produce the deluge. But whether the deluge was occasioned altogether by the natural causes which I have mentioned, or whether some extraneous cause, like Whiston's comet, was super-added to hasten and increase the effects of the natural causes, it appears from Moses's writings, that the deluge continued at the full height during the space of near half a year. After acquainting us, that "the windows of heaven were opened," by which I understand

understand the commencing of the six weeks or six months diluvian rains, and that "the fountains of the great deep were broken up;" by which I understand the breaking and mixing with the waters the rocky shores, which were the mural barriers of the ocean,—Moses tells us, that "the waters prevailed exceedingly upon the earth;" and afterwards, he says, that "the waters prevailed upon the earth an hundred and fifty days;" and after the expiry of the hundred and fifty days, we are told, that "God made a wind to pass over the earth, and the waters assuaged. The fountains also of the deep, and the windows of heaven were stopped, and the rain from heaven was restrained. And the Ark rested upon the mountain of Ararat, in the seventh month," which was exactly at the end of six months from the first day of the deluge.

The stopping of the windows of heaven is explained by Moses, when he says, that the rain from heaven was restrained. By the fountains of the great deep being stopped, I understand the forming of our rocks and strata as a new boundary to confine the ocean within its present bed.

In Moses's history of the deluge, we hear nothing of wind until the height, or a little after the height of the deluge; and then we are told, that "God caused a wind to pass over the earth." The Ark, with man, and all the land animals

animals, was to float upon the waters of the deluge during their progress and increase to the height; and in this state of things, as the Ark was the contrivance, the command, and the care of heaven, it would not be exposed to any real danger from unnecessary winds or tempests. By the ordinary motions of the high diluvian tides, the Ark must suffer; but it was fully able for these agitations, and it was not distressed with storms of wind. But when the diluvian state of the terraqueous globe was past the height, at the end of half a year, from the first beginning of it, and the Ark was grounded upon the mountain of Ararat, then, and not till then, we hear of a "wind passing over the earth,—of the waters assuaging,—of the waters going and returning from off the earth continually,—and of the waters going and decreasing continually, until the tenth month, when the tops of the mountains were seen;—and in the second month, on the seven and twentieth day of the month, was the earth dried," which was somewhat more than a full year from the commencement of the deluge.

It may be remembered, that I took notice above of the effects and marks of strong winds augmenting the force of the high tides of the deluge, after the highest mountains and the elevated plains were formed; the marks of the fury and force of which winds is very evident upon the face of the earth, in dissevering the islands from

from the main, and from one another, and in scooping out the various bays, gulphs, and inlets, which are every where to be found, and which I pointed out above. When I made that cursory speculative survey of the external figure of the dry land, I did not then recollect those words; but I saw such evident marks of strong winds attending and urging the high tides, that I was led to suppose their existence and powerful action and effects; and whosoever will take the trouble to peruse what I have said concerning the gulphs and indentings of the shores, will see the propriety and perfection of Moses's complete though succinct narrative; and the propriety, though imperfection of my remarks upon the external phenomena of the dry land.

Were I to attempt a recapitulation of all the proofs of an universal deluge, I must not only repeat all I have advanced in these mineral essays, but I must also touch at, and explain the whole natural history of the superficies of our globe, below ground and above, all of which distinctly point at that great event. The few instances which I have produced are sufficient, both in number and force of evidence, to convince the candid naturalist of the truth of my propositions; and he that wants further proof and illustration of the doctrine of the deluge will find it in all the phenomena of the Mineral Kingdom.

VII. *Traacts on several subjects relating to
the Mineral Kingdom.*

Of Volcanoes.

The natural history and the phenomena of volcanoes are extremely mysterious and difficult to be explained, because we cannot descend into a volcano to examine circumstances. However, in a work of this nature, upon the Mineral Kingdom, it would be unpardonable to pass over volcanoes in silence, without communicating some of my thoughts upon such a difficult and interesting subject.

I the more willingly enter upon this task, as I am in hopes of being able to throw out some observations which may be of use, in future, to mitigate the calamities suffered by the miserable inhabitants of volcanic regions. I fervently commiserate the dreadful calamities which they have so often and so lately suffered ; and nothing would give me greater pleasure than to be enabled to communicate some hints which may be of use to prevent such dismal catastrophes in future.

Volcanoes

Volcanoes will, in many respects, for ever remain awfully mysterious; at the same time, there are several circumstances relating to them, which may be judged of by analogy.

It is more than probable, that the inflammable matter, which at first was the cause, and continues to be the fuel of volcanoes, is contained in veins which cut and intersect the bowels of the volcanic mountains and the adjacent plains; and I think it may be suggested as equally probable, that those veins are of the same species and description as the mineral veins, in which the useful metals are found; and if this is allowed, I imagine, that useful discoveries may be made for the future safety of the inhabitants of volcanic neighbourhoods; and, therefore, I will suggest a few hints for that purpose.

There are two kinds or descriptions of mineral veins, which are known to trend in a pretty straight line to a considerable distance. Many of these veins have been traced for several miles. The one of these is the perpendicular mineral fissure, called by some miners a *rake vein*, and the other is the *flat* or dilated vein. Rake veins are found to cut the strata in a direction nearly south and north, and west and east. I say nearly, for the bearing of the veins is to the east of north, and to the west of south; but the south and north veins

veins are commonly found to contain the greatest quantities of the metallic ores. The flat dilated veins do not cut the strata at all, but are found between two particular beds of stone, one of which is immediately above, and the other immediately below the vein; and the vein is contained in the space betwixt these two layers or beds of stone; of consequence, the bearing of the flat vein is the same as the bearing of the strata, which, in European latitudes, is less or more to the east of north and west of south. Many of the rake veins are commonly very straight, or close near the superficies of the strata; that is, the sides of these veins are frequently very close together near the surface. I have often seen them so straight for two or three hundred feet down from the surface, that the sides of the veins would not open above three or four inches asunder in all that depth; and yet, nevertheless, they would gradually open further down, to the wideness not only of several feet, but of several yards; and it is generally in these wide concavities of the veins, that the greatest bodies of the metallic ores are found, and very probably, it is in such receptacles that the greatest quantities of the volcanic fuel is lodged.

The flat veins found between the strata are not to be investigated upon the same principles as the rake veins; nevertheless, these also are fre-

quently very straight or close near the superficies of the strata. The space between the two strata which constitute the upper and nether side, or roof and sole (as they may be called,) of this vein, are seldom regular, or equidistant. In some places they come close together, and continue so for a less or greater space, and in other places or parts of the same vein, they open asunder, and form enormous concavities, which frequently trend in a horizontal direction; and the direction or bearing of such concavities is generally north and south, or between that and the collateral points of north-east and south-west.

The east and west rake veins intersect those which trend from south to north, nearly at right angles; and they cut the strata in a line nearly right across the bearing, and parallel to the declivity or slope. The flat veins situated between the strata, likewise open into concavities from west to east: That is, besides the concavities in the flat veins mentioned above, which run parallel to the bearing of the strata, there are also found in them, concavities which run at right angles across the other, in a line nearly from west to east, which comes to be parallel to the line of declivity of the strata; and as that is the case, it is easy to conceive, that the one end of these last mentioned cavities point up toward the surface, and the other end points slanting downwards

wards into the body of the earth, with a degree of slope exactly equal to the declivity of the strata in that particular place. I need not here point out the very great variety of the declivity or slope of the strata in different places. That point is fully explained in my treatise upon the natural history of coal. I will only observe here in general, that the line of the declivity of the strata in different places is found in all the degrees of slope between the vertical and horizontal positions of the strata. From what has been said concerning the east and west concavities of the dilated veins, it will clearly appear, that the east end of each of these cavities will gradually dip down under more and more cover, until at last they arrive under a prodigious weight and strength of the incumbent strata, even up to many hundred fathoms perpendicular of solid rock. There are found some rake veins running in collateral lines between the two lines above-mentioned; but as these are only inferior strings branching off from the capital south and north, and east and west veins, they only continue their course or line of bearing to a short distance from the veins which they branch out of, and then they come to nothing; that is, the sides of this string, which for a while cut the strata in an oblique or diagonal direction, come close together at a short distance from the capital vein, and at
last

last ends in a mere crack in the strata ; and a little further forward, the strata are found solid, without the least symptom of any vein in the line of bearing.

From this investigation, it appears, that the capital mineral veins which are found within the solid superficies of the earth, trend in a direction a little to the east of north, and to the west of south ; and that what are called east and west veins, are seldom found to contain very considerable quantities of the metallic ores ; and I have no apprehension of their containing great quantities of the volcanic fuel. There is a very good natural reason for the fruitfulness of the north and south veins ; that is, for their containing the greatest quantities of mineral matter, which I have explained in a treatise of the natural history of mineral veins, &c. However, this is not without exceptions. In some few mining fields, the east and west veins are most productive ; at present we will take it for granted, that the north and south veins contain most mineral matter, and let those who are chiefly concerned, compare what I advance with experience and matter of fact. From this sketch of the history of mineral veins, it appears to me very evident, that the greatest quantities of the volcanic fuel is lodged within the solid superficies of the earth, in veins and receptacles which have nearly

ly a north and south bearing, from the mountain or other place where the volcanic fire first broke out; and that the volcanic fires and consequent excavations will advance below ground in the same direction. Now, if this is found to be true, we shall be enabled to lay down such beacons, cautions, and rules, as will be of general utility for the safety of the inhabitants in the neighbourhood of volcanoes. I write only from my own observation, and real knowledge of the interior structure of the superficies of our globe; and from my knowledge of the structure, disposition, and bearing of the strata of rock, which compose the superficies of the globe in all parts of the world, it appears to me, that the bearing of the strata in the island of Sicily, which suffers so much from volcanoes, should be nearly in a line from S. S. W. to N. N. E. and consequently, that the bearing of the veins which contain the volcanic fuel, should trend nearly in the same line of direction; and I think, that Messina, and those parts of Calabria which suffer so much from earthquakes, are pretty much in this line.

If, upon examination of circumstances upon the spot, it is found, that the site of Messina, &c. is nearly upon this point of the compass from Mount *Ætna*, or any where between the cardinal point north, and the collateral point north-east, and that the volcanic regions of Calabria
are

are in the same line, that is, nearly N. N. E. from *Ætna*, it may be concluded, that my observations are founded in truth, and that there is no safe ground for founding a city, town, or harbour, any where near that line.

There are certain classes or arrangements of strata, of particular characters and qualities, which accompany one another in longitudinal districts upon the face of our globe. These arrangements of concomitant strata are found in patches of lesser and greater dimensions ; but generally extending further in the line of bearing than in the line which crosses the strata. In some of these distinguishable classes of strata, seams of pit-coal are most frequently found, others produce the greatest number of lead and copper mines, &c. and it is highly probable, that there are certain arrangements of co-natural strata, in which the greatest quantities of the volcanic fuel is lodged. This article, in the natural history of the Mineral Kingdom, deserves to be carefully examined in volcanic countries.

If it is judged, that the hints which I suggest upon this subject come near the truth, let the intelligent naturalist take my book in his hand, and traverse the neighbourhood of Mount *Ætna*, and between that mountain and Messina, and let him examine the nature, colour, and quality of the several strata in that line, and likewise in the
 continuation

continuation of the same line into the volcanic regions of Calabria. I suppose that much of the surface of the ground near *Ætna* will be covered with lava, ashes, and other rubbish, where the strata cannot be seen; however, he will see them in several places in that line, and especially upon the shores of Sicily and Calabria. When he has satisfied himself with respect to the quality and characters of the prevailing strata in that line, then let him examine the strata, either inland or along the shores of the Mediterranean Sea, wherever he can best see them in a line from west to east, right across the bearing of the strata, which we have supposed to be about N. N. E. and S. S. W. and when he meets with an arrangement of strata, or rocks of a quite different quality and colour, &c. from those found in the volcanic line, he may conclude, that he is in a place of safety for the foundation of a city or harbour, &c. especially if he is far enough east or west over the line of the supposed range of the volcanic strata. The principal crater on the summit of Mount *Ætna* may be supposed to be the center of the volcanic ground, though that is a little uncertain, as we cannot positively determine whether the veins and excavations of that mountain deep down have advanced farthest towards the east or west: However, perhaps, we can fix upon no better point than the great crater,
from

from whence to draw the line towards Messina and Calabria. If the superficies of the strata about the foot of the mountain could be seen for lava and other volcanic rubbish, the naturalist could guess pretty nearly what is the breadth of the volcanic ground in the island of Sicily; but as I suppose he cannot see the strata about the mountain, he must be the more careful to investigate circumstances upon the sea shores, the banks of rivers, and other places near Messina, and in Calabria, where the superficies of the strata are to be seen; and when the best judges of these matters have acquired sufficient degrees of knowledge of the distinguishable characteristic qualities of the strata of the volcanic region, to be enabled to form a safe and prudent plan for the site of sea-ports and cities, far enough from dangerous ground, then let Messina, and all the regions in Sicily and Calabria which have suffered, and are in most danger of suffering such dreadful and destructive ravages from the earthquakes and volcanic eruptions, be abandoned by the generality of the people, and adapted to husbandry only, which requires but few people to inhabit those places, who can easily remove for a while in time of danger, and the husbandmen may be instructed, from time to time, which way to fly in time of danger, in a right direction, to places of safety; that is, to fly off the
line

line of the volcanic ground, to places which suffer least from these calamities. I cannot help considering it as presumptuous, and in the highest degree dangerous, to think of living in Messina, or any other of the towns or harbours in Sicily or Calabria, which have recently, or at any former period suffered by earthquakes and eruptions; because the same places are in continual danger of suffering the same over and over again, and every succeeding shock should be worse or more dangerous than the former; because the rocky crust which lies above the volcanic excavations, and under such town, harbour, or other place, is greatly weakened by being shaken, rent, and shattered with former shocks, and there are only two chances in nature that can ever make those places safe for the habitation of man. The one of these chances rests upon the supposition, that the whole magazine of the volcanic fuel in that region may be entirely exhausted, of which we can say nothing, as we cannot survey those magazines to enable us to judge of their extent and duration. The other chance is, that an earthquake or volcanic eruption should open such a breach in the bed of the sea, as to make room for the ocean to rush down in such a vast body as suddenly to fill up the excavated receptacles of the volcano, which must soon extinguish it altogether; but

both these chances are too distant and uncertain ever to be trusted. It must happen, that several repeated volcanic concussions dry up many springs and rivulets, by which a great quantity of water is let down into the excavations of the volcano ; but such comparatively small quantities of water have a direct tendency to aggravate the evil, and to make the volcano ten times more dreadful and mischievous, as every drop of that water is evaporated and reduced to highly rarified steam, by the prodigious heat of the fiery caverns of the volcano ; and the experience we have of the steam engine enables us to form some idea of the prodigious force of steam, when it is greatly heated and confined within limited bounds.

When a copious stream of the atmosphere gets access into a volcano, and, by its density and weight, rushes into the remote excavations, and gets under or behind extensive clouds of steam, the consequences must then be dreadful. The expansion of the steam, before the external air is so copiously admitted, fills all the volcanic spaces ; but the coolness of the air in part condenses the steam, which makes room for still greater quantities of air to rush in ; but when the steam is again fully expanded, and the admitted air highly rarified by the excessive heat of the volcano, the united force of both is sufficient to convulse
the

the whole globe, and to rend asunder the strongest bars of the earth, if it does not find a thin enough crust of rock through which to burst a passage. What are the explosions of gun-powder, and any force of steam which we can bring to act, but trifling experiments, and children's play, in comparison of these mighty operations and effects. It is only in the volcano that they act like the great works of nature. When sufficient quantities of these powerful agents get behind melted and unmelted matter within the receptacles of the volcano, and are fully rarified, when the explosion happens, if the vent is wide enough, it will drive out every thing before it through the mouth of the crater : But if the passage is too straight, or is obstructed by falls of the rock within, by congealed lava, or otherwise, in that case, it must and will burst up the rock, and make a new vent or passage, as it happened lately in Sicily and Calabria.

From all these considerations, when viewed jointly and separately, there appears no place of permanent safety within the line and limits of the volcanic fuel, which I wish to be able to point out, and which I hope will in time be found and understood ; and as there is no permanent safety, neither is there any possibility of knowing when or where the earth may be convulsed and rent again and again within the old volcanic limits ;

mits ; nor is it easy to judge how far the subterranean fires may advance in the line of bearing, which we have supposed to be in Sicily and Calabria about N. N. E. and S. S. W.

These hints are well intended. They flow from a fervent desire of doing good. Let them not be rashly condemned without examination and a fair trial. They may not be readily understood by every body ; however, they are all founded either in experience, or upon solid principles ; and, therefore, they deserve to be seriously and thoroughly investigated ; and, perhaps, these hints being thrown out by a plain practical man, may be the means of suggesting to naturalists such further discoveries and improvements as will conduce to the safety and happiness of the inhabitants of Sicily, and all other volcanic countries. For if proper rules can be laid down for the safety of one country that is disturbed by volcanoes, upon the principles of mineral philosophy, it is to be supposed, that the same rules will hold good every where, making proper allowances for the different bearings of the strata in different latitudes. Now, the bearing of the strata at the equator must be true south and north ; and as we recede from the equatorial regions towards the northern tropic, the bearing of the strata inclines gradually towards the east of north ; and as we advance from the tropics towards the north-pole, the bearing

bearing of the strata inclines gradually more and more, until at last it comes to be north-east, and they trend gradually towards the east to the south of the equator, in like manner as to the north.

It may be proper to observe here, that, in some particular circumstances, the strata in a small spot or district may, and do vary and deviate from the true general line of bearing; as, for instance, when the strata lie exceeding flat in the horizontal position, they are in that case found to wave up and down, and to dip this way and that; and while they continue thus to wave up and down, they acquire many different bearings and slopes, frequently towards all points of the compass. But this accident is not of any great continuance. It only happens upon a small scale, and in a small district, but does not in general affect nor alter the true line of bearing. The different bearings and declivities of the strata, with the natural reasons or causes of that diversity, has been fully investigated and explained in a former part of this work, to which I refer. With respect to our present enquiries, it is proper to take it for granted, and naturalists viewing circumstances will find that I am right, and they can improve upon my hints, so as to become masters of the natural history of the strata in the neighbourhood of the volcanoes which they are acquainted

acquainted with, and they will thereby be enabled to make useful communications to the world; and if they will read my Natural History of the Strata of Coal, and my observations about the stratification of the superficies of the globe, they will find such assistance, in acquiring the knowledge of the construction of the solid superficies of the globe, as will make their investigations easy, pleasant, and successful. In the mean time, allow me to ask, how they can be better employed, than in attempting to be able to point out such rules and cautions for the future safety of such numbers of our brethren as are still exposed to those dreadful calamities, which have swallowed up and destroyed thousands in all parts of the world that are infested with volcanoes?

By these enquiries and investigations, naturalists may become the ministers of health and safety to numbers of mankind; and how can they attain greater honour or happiness! And what signifies the idle selfish pomp of learning and knowledge, if it is not exerted for the good of the world?

I will add, in this place, a strong argument to enforce the examination of this subject, which is this: We find, in experience, that the Almighty seldom or never sends a great calamity to scourge the children of men, but he also, at the same time, points out, or puts in our power an antidote

dote or means which wisdom and caution may lay hold of, and use to mitigate the severity or extreme rigour of such calamity.

A great many examples of this might be given to shew, that the Alwise Governor of the world, in the midst of judgment, remembers mercy, and puts the means of deliverance or of mitigation in the power of prudence and exertion ; but I will only point at one instance, viz. the small-pox, as one of the severest scourges of the human race.

In some countries it sweeps away whole tribes at once, and in almost all places, prodigious numbers are destroyed by this loathsome malady ; but now, and even long ago, Providence pointed out inoculation, as not only a happy means of mitigating the rigorous and destructive severity of this dreadful malady, but in a great measure as a perfect antidote ; for many physicians in Britain have inoculated thousands without hardly losing one, and almost without leaving a single mark of their patient's ever having had the small-pox ; whereas the few who escape with life, when smitten in the natural way, without being inoculated, find blindness and deformity are but too commonly entailed upon them as long as they live.

It was a long time before inoculation prevailed among us in all parts of Britain. I wish to God, that now, when philosophy and science are arrived at such degrees of perfection in Europe, and
now

now that earthquakes and volcanic eruptions are become so common, and so very destructive in many parts of the world, that proper means to mitigate and to shun the dismal effects of this calamitous scourge could be found out, and sure rules formed for the future safety of the inhabitants of those countries. I think this attainment not only possible, but also practicable; and this persuasion is not only founded upon a fervent desire that the above hints may answer the design for which they are written, but is also founded upon the equal, wise and benevolent providence of God, who never sends a scourge, and permits a severe evil to visit mankind, but he also sends the means of escaping, or at least of mitigating that evil; but many of these means require wise and strenuous exertions, and too many of us are like negligent sailors, who forget, when one storm is over, that they are still in danger, but content themselves in their present safety, and never think of putting their ship in proper trim for weathering the next storm, until it overtakes them unprepared.

It is said, that necessity is the mother of invention, and I hope, that the great and pressing necessity of this case, will prompt those who are chiefly concerned to attempt the remedy, or at least the mitigation of this great evil; and there appears to me no sure remedy in nature, or, in
other

other words, no sure means of mitigating this evil effectually, but for the bulk of the inhabitants of such countries to shun the line of the volcanic ground, and to leave those dangerous situations, where so many of their brethren have perished in a moment, to be occupied by farmers only, who should live in tents, or in other slight habitations, which could not crush them by their fall, and which would be easily reared up again when thrown down by the concussions of earthquakes; and these farmers should be instructed which way to fly from danger to safer ground; and, moreover, they should be well instructed to understand and observe the signs and symptoms of approaching danger, that they may always have it in their power to provide for their safety by flight. I have no manner of doubt of there being external signs and appearances, and interior symptoms and warnings of approaching danger, which will be almost infallible when well understood and well attended to. There will be appearances in the clouds, which the peasants can easily be instructed to observe, and no doubt the atmosphere will be in a changeable imperfect state before an earthquake. In short, whatever the peasants can see and hear as warnings of danger, they can be easily instructed in the knowledge of; and it is the province of intelligent naturalists to investigate the causes of effects, and the effects of causes. It

has been observed in many parts of the world, that the atmosphere is uncommonly agitated, and in an imperfect state, all round the globe, before any great earthquake. And it is said, that rumbling noises are heard under ground in volcanoes for some days before a great earthquake and eruption. Perhaps part of the cause of these subterraneous noises may be occasioned by copious streams of air and steam rushing out when violently heated through passages, which are yet pretty clear and open ; but that, during this time, streams of lava are propelled forward from remote parts or excavations of the volcano ; but when this mighty stream of lava accumulates in a straight mine or passage, then the catastrophe is near. The mighty gusts of volcanic respiration are at an end ; but there is a quantity of air and steam behind the lava, which is increasing rapidly by the continual supply of water from a thousand vents, which is suddenly converted to steam ; and when this steam is sufficiently heated, then an earthquake ensues, and the lava is either propelled to the surface by some of the old apertures, or new breaches are made where the rock is weak, as happened lately in Sicily and Calabria. Now, if we allow of this supposed violent respiration of the volcano, for a few days before the earthquakes and eruptions, it will sufficiently account for

for the uncommon agitation and imperfect state of the atmosphere in all parts of the world.

I observed above, and it is well known, that many springs and rivers are dried up by volcanoes, and all the rain and snow which falls upon volcanic ground, must all find its way down into the subterraneous excavations, excepting what is immediately evaporated upon the surface, and no doubt much more water goes down into volcanoes than we can easily imagine, and especially when in their progress, they advance under rivers, rivulets, lakes, and some of them even under the sea itself. Now, what becomes of the prodigious quantities of water that percolates the pores and crannies of the strata, and that rushes down through the natural and accidental cracks and fissures of such extensive rocks as cover, and are situated upon both sides of some ancient volcanoes? Every drop of it is dissolved and converted into steam by the prodigious heat of the volcano. Now, a prodigious quantity of water, evaporated into steam by such a heat as that of the volcano, will soon fill all the excavations of the volcano like a thick cloud; and while this vapour is fed by continual and copious supplies from the feeders of water, and the extraordinary heat, the steam will so effectually fill all the receptacles of volcanoes, as to exclude and prevent the admission of the external air into any of those receptacles.

I must not be understood to mean, that the external air is absolutely excluded from every part of the volcano. The fire could not exist without a communication of less or more of the external air; and the extreme degree of cold which gentlemen who visit volcanoes have found in some narrow caves and passages in the sides of volcanic mountains, is a clear proof of the air rushing violently through those fissures to fan and feed the fires below; but what I mean is this, that the great heat, with a thick and strong cloud of steam, will fill all the great excavations of the volcano, and effectually exclude the external air from entering through the crater; nor can it possibly get admission into those receptacles thro' the crater and common main passage, while the heat and steam continues in full force.

These hints are not merely conjectural. They are founded upon observation and analogy, in comparing great things with small, which is the surest way of coming at the truth in such abstruse disquisitions as these. Steam from boiling water raised by great heat, and confined within any vessel or close receptacle, is far stronger and more powerful than the weight of the atmosphere. This is a fact very well known, and now clearly proved by Mr Watt's steam engine. The specific gravity or weight of the atmosphere, when pressing upon any surface above a vacuum,

is

is upwards of fourteen pounds avoirdupois upon every square inch; but it is now found, and clearly demonstrated, by Mr Watt's steam engine, that the force of steam is much greater than the specific gravity of the atmosphere, so as, when confined, to press upon a surface with a force considerably upwards of twenty pounds upon every square inch. This fact is very well known, and daily experienced in working Mr Watt's improved engine; and moreover, we see this fact continually exemplified by observing the steam issuing out, when the steam clack or valve upon the top of an engine boiler is opened. When this valve is first opened, the steam rushes out with a force and noise proportioned to the size of the boiler, and the degree of heat the fire is raised to below, and it continues to rush out with violent force for some time; however, by and by, when no more fuel is cast into the furnace, and the fury of the heat below the boiler is abated, the rushing noise of the steam ceases; and when we look at the valve, we see that no steam issues out for the space of about two or three minutes; but in a little while we hear the roaring of the steam again as loud as at the first, and we see as copious a stream or cloud of it rushing out as when the valve was first lifted; however, it does not last so long as at first before it ceases again, and these alternations continue in
some

some degree until the heat below is so far abated as to raise but little steam in the boiler, tho' the gusts of steam issuing out grow weaker and weaker each time. The phenomenon of the roar and force of the steam ceasing, and being renewed again alternately, attracted my curiosity, and engaged my attention to examine the cause; and I soon found, that it could be no other than the admission of a quantity of the external air into the boiler through the valve, and that air, by its gravity, rushing down beneath a quantity of steam. This admitted air, by its coolness, will in part condense the steam it comes in contact with in the boiler, which will make room for more air; but when the steam is again dilated to its former state, and the admitted air is rarified by the heat of the boiler, both rush out again with renewed force and noise. Now, it is observable, that for a few minutes after the valve is lifted, the steam rushes out constantly with force and noise, for during this space of time, the force and power of the steam exceeds the force or weight of the atmosphere; and therefore, the external air is perfectly excluded from entering the boiler while the steam continues in such force; but when the heat under and within the boiler is so far diminished, as to bring the steam within the boiler in equilibrio with the weight of the atmosphere, in a little time the air gets the better

better of the steam, and rushes copiously down into the boiler, through the same vent as the steam before rushed out; and while the air is rushing down through the aperture of the valve, the noise ceases, and no steam issues out, nor is there any more appearance of steam about the valve for a few minutes than if the boiler was cold and empty; but when the steam is again sufficiently heated, and the admitted air rarified, the external air is again conquered by a superior force, and the steam rushes out again with force and noise; and so on alternately, until the water in the boiler is so much cooled, as not to be in force to exclude the atmosphere at all. We may call this the respiration of the boiler; and if we will suppose such a respiration in the volcano, and consider the different scale of the receptacles of the steam, we need not wonder if the atmosphere is uncommonly agitated some days before a great earthquake. We do not know, nor can we pretend to explain, what effects the collision of a copious stream of atmospheric air may have, when rushing in and passing over the surface of an extended flood of boiling lava, in generating electrical fire, and in producing an electrical shock proportioned to the nature of the place and the quantity of the materials; which shock may contribute its share with
the

the other volcanic powers to produce mighty earthquakes.

There is an inflammable vapour found in some coal mines and other places in the bowels of the earth, which often collects in such remote mines and other parts of the works as are scarce of air; that is, where there is not a sufficient current of air to dissipate and carry off this mephitic vapour. When this inflammable vapour collects and condenses in the cool recesses of remote mines, or other parts of the works, though several hundred yards from the bottom of the shaft, if touched with a lighted candle, it instantly takes fire, and goes off with an explosion like gun-powder, and with a force perhaps superior to it, which often scorches and kills the persons who happen to be near it; and it has frequently been known to sweep every thing in its way to the shaft, and to rush up the shaft or pit with such force and violence as to carry every thing in its way, and the whole apparatus of the shaft, high up into the air. Sparks of fire struck from steel and pyrites does not ignite this vapour; and therefore, miners often work in it by the light of sparks raised by a steel mill from pyrites, where they dare not use a lighted candle.

Now, here is another powerful agent found below ground, which, for any thing we know to the

the contrary, may be joined with other volcanic forces ; and when such a small quantity of this vapour as is contained within the space of a few cubical feet, and a small quantity of gun-powder, when properly confined, are capable of doing such mischief, and of proving so powerful, what may we not suppose the united force of the volcanic powers capable of doing, when they are in such immense quantities, and excited by such prodigious fires in the extensive caverns of volcanoes ? But here all computation and even conjecture fails. We are not capable of forming a proper judgment of these stupendous and astonishing secret operations of nature. All we can do in such cases as these, is to have recourse to the effects to enable us to judge of the cause.

There is yet another very powerful agent in nature, which is pretty well known, though not so well understood ; I mean electricity, and electricity is the action of fire. If we attentively examine this matter, we shall soon discover that fire is the most active, and I believe I may venture to say, the most powerful agent in nature. Before we attempt to apply the force or operations of electricity to any of the phenomena or accidents of earthquakes and volcanic eruptions, it may be proper to make a few observations concerning the nature and properties of fire.

Most of the philosophers of all ages have told us, that the gross matter of our system of things is composed of four simple elements, viz. Fire, Air, Earth, and Water. Of these supposed four elements, I can find but three, namely, Fire, Water, and Earth; the air or atmosphere being a mixture or combination of the finer particles of all the three elements of Fire, Water, and Earth: Of these three elements, fire seems to be the only material principle of activity, life, motion and force in the universe. The other two elements are naturally dead and inert, and incline to absolute rest. Fire, on the contrary, is all activity, power, and progressive motion, when in any degree of liberty, from too close a confinement and union with the other elements of earth and water. The rays of the elementary fire dart from the Sun to our globe, with sufficient force and velocity to cut their way through an unclouded atmosphere, until they reach the surface of the globe, and then ascend again slowly, mixed with the watery vapour which they produce by resolution. These rays of fire, emitted by the Sun, or moved by him, dash against the surface of our globe, and of all bodies upon it, with a degree of force and violence equal to the velocity of the motion; and as all parts of the surface of the globe, and of all bodies animate and inanimate, have some degree of humidity,

humidity, the violent collision of the rays of fire melt and dissolve some part of this humidity into steam or vapour; in which humid steam the pure elementary fire is absorbed, mixed and united so effectually, that it ascends up into the atmosphere involved in the watery vapour. This is in some measure evident to our senses. After a warm shower of rain in a sunny day, we often see a thick and copious vapour of steam rising and ascending from new plowed land, from green banks, and many other parts of the surface of the earth; which is a clear and ocular proof of the great quantities of water which the rays of the Sun melt and dissolve in warm weather. Every motion of the atmosphere upon the surface of the earth, and upon the surfaces of all bodies, melts and dissolves a quantity of the humidity it comes in contact with, in proportion to the violent collision of its motion.

In strong winds, vast quantities of moisture is carried up into the air, from the surfaces of the land and water, &c. This is evident to our senses, by the sudden drying of the surface of the earth. The quantity of water which is dissolved and evaporated by the contact and collision of the element of fire, and carried up in any given time, is so immense, that the lakes and rivers, and even the ocean itself, would be soon exhausted, and the quantity accumulated over head in
the

the regions of the atmosphere, would soon involve our globe in darkness and destruction, was it not continually separated from the fire which carried it up, and let fall down again in rain and snow, &c. and on the other hand, if the atmosphere was not continually supplied, renewed, and refreshed, by plentiful humid cooling vapours from the surface of the globe, the air itself, and the whole surface of the earth, would be soon burnt up, by the ardent and powerful action of the element of fire. Thus, we see, that the ordinary operations of nature have a continual tendency to surcharge the air with too much moisture; but the watery vapour carried up into the atmosphere, is in part separated from the fire which was united with it, and gave it that expansion and levity, by many ways either altogether unknown, or very imperfectly comprehended by us. I will not attempt any particular explanation of a subject so much out of my sight; however, we may venture to say in general, that any increased degrees of heat or cold in the regions of the atmosphere,—every collision of the clouds, and every brisk motion of the atmosphere, releases much fire from the watery vapour, by the collision and attrition of the parts of the atmosphere in motion; and of course, much watery vapour is at the same time released or condensed. Sometimes the separation of the latent fire from the clouds

clouds and atmosphere, is in such great and increased quantity as to become visible; as, for instance, in shooting stars, or other fiery meteors, which are seen in a clear night, in lightning, and the aurora borealis. The aurora borealis, which has puzzled philosophers for ages, is easily accounted for, upon this hypothesis.

If once we are convinced that our atmosphere is composed of fire, water and earth, and that there is such a reciprocal, progressive, or rapid interchange of the union and decomposition of these elements, as we endeavour to establish, the phenomenon of the aurora borealis will become of easy solution, and almost evident to our senses.

Every accelerated motion of the atmosphere, or of any accumulated vapour, has a tendency by violent attrition to disengage the fire from the watery vapour. In the aurora borealis, we evidently see a thin cloudy vapour in violent motion; or we see the corruscations and light of streams of fire, which fire is copiously discharging from the atmosphere, and is flying upwards, which may be called a vertical wind. But of all the causes in nature of the decomposition and separation of the fire of the atmosphere, its approach to a burning fire, or to any great and violent heat, is the most powerful and hasty. It is very well known, that a current of air is necessary to fan and feed our burning fires; but it is
not

not quite so generally known, that in this operation of nature, there is a decomposition of the texture of the atmosphere; and that, when the air approaches the heat of the fire, the watery part of it flies back, and the latent elementary fire of the atmosphere rushes forward, and, by its collision, dissolves the viscid teguments, which contain the latent fire of the fuel, and when both are copiously released, the sensible heat is proportionally increased.

That the atmosphere is plentifully mixed with latent elementary fire, is evident from its being procured several ways by attrition, as in artificial electricity, the friction of dry axles, the peg and board, &c. Now, when a copious stream of the atmosphere enters the mouth of the crater of a volcano, the heat of this prodigious furnace will cause the watery parts of the air to fly back; but the latent fire will rush forward to join its native element in the excavations of the volcano, and a vast increase of the elementary fire from the atmosphere will soon bring matters to a height, and produce dreadful earthquakes and eruptions.

Fire in one state, condition, or modification, or other, seems to be the most powerful and universally active principle and agent in nature. I do not know but it is the only active principle, and natural cause of force and motion in the universe.

It

It is fire that thunders in the clouds, and roars in the winds, and tears up the superficies of the earth in hurricanes, and undoubtedly it is fire that rends the rocks asunder, and shakes the foundations of the solid globe in earthquakes.

And it is the different mixtures, modifications, conditions, and motions of this element that produce all the mild, beneficial, and salutary operations of nature. It is fire that sustains the life, and promotes the growth of plants and animals; it moves gently in our mild salubrious fluids, and effervesces more fiercely in many hot and pungent liquids. In short, fire seems to be the only active principle in every fluid, and in every moving body; and we can set no bounds to the power of this mighty agent.

I could make but little by further attempts to explain and illustrate the inexplicable operations of volcanoes; and as I think that I have now suggested sufficient hints to throw such gleams of light upon this naturally dark and difficult subject as may be of use to real philosophers, I will say no more upon this topic at present.

All these reflections authorise us to conclude, that dreadful earthquakes and eruptions will frequently happen somewhere in the line of old volcanoes; and it is impossible to know when or where they will be most violent and destructive in that line.

What

What I mean by the line of the volcanic ground has been pretty fully explained above, where it was observed, that the several species of mineral veins, which are found by experience to contain the greatest quantities of mineral matter, run in a line parallel to the bearing of the strata. This point being considered as an established fact, it will follow of consequence, that whether the volcanic fuel is chiefly contained in veins or in strata, in rake veins, or in flat dilated veins, which are situated between the strata, it will run in the same longitudinal line of bearing. I have some reasons for being persuaded, that the inflammable matter, which is the fuel of the volcanic fires, is not contained in strata properly so called; though it may, and I am persuaded that it frequently is contained in the flat veins situated between the strata, which were described above. One reason for my rejecting regular strata of volcanic fuel is this: It is well known, that in the constructure of the stratified parts of the superficies of our globe, the one side, or the one edge of the several strata come quite up to the superficies of the solid part of the globe, tho' earth, clay, gravel, sand, &c. is frequently found of various depths lying above the superficies of the solid strata.

In this view of the subject it appears, that the one side or edge of every stratum comes up to the

the superficies of the solids ; and therefore, if the volcanic fuel was contained in regular strata, it would follow, that when a volcano was once kindled, it would burn forward in a line quite up to the surface of the ground, which indeed would make that line a little troublesome ; but as the volcano by this means would have regular breathing places, as we may call it, by communicating with the surface every where as it advanced in the line of bearing, few or none of the dreadful accidents attending volcanoes, such as earthquakes and eruptions, would happen. This we know by experience, as far as analogy will reach.

Seams of pit-coal are regular strata. They are sometimes set on fire by accident, and burn below ground for several miles. Now, this conflagration not only burns quite up to the superficies of the solid strata, but it also burns such earth, clay, &c. as lie immediately above the solids in the line of bearing, and the several substances which come in contact with the fire at or near the surface, in the line of the crop or basset of the coal, are frequently vitrified, and run together in vast masses of slags resembling lava ; but neither earthquakes nor eruptions ever happen from these subterraneous conflagrations, no doubt for the reason I gave above, viz. because this subterraneous burning communicates with the surface all along the line of

the basset of the coal as it advances ; and, therefore, the evaporation of the water which goes down, and the rarification of the air that fans the fire continually, find an easy passage to the surface. This is a pretty good example to enable us to judge of these matters by analogy.

It has been observed, that mineral veins are frequently checked at the surface, the two sides of the vein being squeezed close together above ; but besides this cause of preventing the respiration of the volcanic fires, strata of different qualities may be spread over the bassets, vertex, or tops of the mineral veins in the valleys, which do not reach up to the site of the first craters upon the mountains. Strata of pit-coal, and their concomitants, are found in valleys, which do not ascend the high mountains of the coal countries. Veins of volcanic fuel basset out in the summits of high mountains, where they are first ignited ; but when they burn down towards the bases of the mountains, these veins may be covered by other horizontal strata, containing no such veins nor fuel.

Mineral veins, whether vertical or horizontal, are exceedingly unequal in their capacities in different places of the same vein, frequently opening out to vast and spacious concavities, and again contracting at a small distance into narrower bounds. . Now, it is reasonable to suppose, that the

the capacious receptacles of these veins contain the volcanic fuel ; and that, when the combustible matter is consumed out of these cavernous receptacles, they will be greatly enlarged by the vitrification and decomposition of vast quantities of such matter that is not combustible, as comes in contact with the prodigious fires and heat of the volcano ; and it is as reasonable to suppose, that it is in these enormous caverns of fire that the causes of earthquakes and eruptions are generated. We cannot tell how deep or how far below ground these prodigious excavations may reach ; but we know, that they can have no communication with the external air, but by the craters, or other apertures which the several earthquakes have made ; and, therefore, no respiration nor perspiration of the steam and rarified air, can possibly happen here, as in the conflagration of a stratum of coal. It must either issue at the common apertures, or burst a new passage elsewhere ; and fatal experience makes it but too evident, that it frequently does burst a new passage in great and destructive earthquakes, as happened lately in Sicily and Calabria.

Although the mineral veins, supposed to contain volcanic fuel, are very unequal in the capacity or dimensions of the concavities, they are nevertheless pretty regular in the line of bearing. I hinted before, that several veins run parallel to

one

one another in mineral ground, and no doubt this will happen in volcanic ground. In some mining fields we meet with short veins, which cut right across between two capital parallel veins, and tack them together without crossing them, like a cross road, which leads in a right line across between two parallel roads, and joins them together, but goes no further. These short cross veins are frequently well replenished with the mineral ores; and so they may with inflammable matter in volcanic countries; and if so, then the fire will easily communicate from one parallel vein to another. I hinted before, that many of the strongest and most productive mineral veins are piped; that is, are formed into long and high concavities, which run parallel to one another; and these pipes frequently point downwards in a slanting direction into the body of the earth.

These pipes resemble a number of long vaults, or arched cells, arranged parallel to one another, only not so regular. It is impossible for us to know how deep the veins and these pipes in them strike down into the body of the earth, whether the veins dip down precipitately, or with an easy gentle slope; and, therefore, it is impossible for us to know how deep the volcanic fire may penetrate; but this one thing, however, we may assure ourselves of, viz. that the deeper and more extensive the subterraneous excavations are, the
more

more dangerous the volcano, and the more mischievous and extensive its effects; and the reason is obvious, viz. because the deeper and more extensive the excavations are, the more room there is for the reception of steam, air, &c. the which, with the agency of the volcanic fires, I have proved to be the efficient cause of earthquakes and eruptions.

It cannot be denied, that the excavations of old volcanoes are amazingly extensive.

The immense quantities of lava, and other matter ejected out of them, proves this to a demonstration; and, therefore, it may be a query with some, how it happens, that the ground above these extensive excavations does not give way and fall in, not only around or near the original crater, but even every where in the course or line of the progress of the subterraneous fires, and produce numberless gulphs and chasms both dangerous and frightful to behold?—I answer, if the volcanic fuel was generally contained in regular strata, the earth would so fall in, because the combustible stratum or strata being consumed from under those immediately above them, the superincumbent strata would infallibly fall down when undermined to a vast breadth and length; and this must happen in the whole length of the volcanic excavations, and as far in breadth as they are undermined below: But this not being the case,

case, is another strong proof, that the fuel is lodged in mineral veins, which not only strike down deep into the earth, but are also frequently of a piped form, as we hinted before, which pipes sometimes stand nearly perpendicular, or with a considerable slope; and, therefore, every part of the intervening rock which separates the pipes from one another, and which separates the several veins from one another, stands as a sure substantial pillar fixed upon its own base; and it is known by observation and experience, that the concavities of mineral veins more frequently expand or open out deep down than near the superficies of the strata. Many of the cavernous excavations of volcanoes will therefore, according to this piped form of the veins, be exceeding wide deep down, and exceedingly capacious; but they will assume an arched figure, with, in many places, a thick and strong crust of rock above the arched excavations, which does not contain any combustible matter.

The natural history of the solid superficies of the globe is a subject of difficult investigation; and there are but few, even of our philosophers and naturalists, who are well acquainted with its construction, which makes it the more necessary for me to be minute and circumstantial in explaining some particulars. In the practice of mining, we sometimes meet with what may be called
 accumulated

accumulated or concentrated veins; that is, a number of veins or mineral fissures, containing rich ores, the one end of which converge and meet in a common center, and the other end of each of them diverge and spread out from this center to some distance, though generally not very far.

It frequently happens, that a vast body of ore is found in the center of this accumulated vein; and when the ore is dug out, a most tremendous gulph is opened below ground, which is sometimes of an irregularly arched or conical figure; but whatever figure the excavations assume, there is nothing in the practice of mining so awful and dangerous as the waste or excavations of an accumulated vein.

Now, it is fair and reasonable to suppose, that there may be vast accumulated veins of fuel in some volcanic mountains, perhaps of much greater extent and dimensions than we can easily conceive; however, the excavations of these, though vast and extensive, are nevertheless of an arched or conic form; and therefore, the superficies is supported, and does not fall in. These subterraneous excavations may be compared to some immense Gothic temples, which, though of vast dimensions, the roof lofty, and composed of massy and ponderous materials, yet the fabric is firm and durable, because it is supported by walls, buttresses,

treffes, and pillars, proportioned to the immense weight of the superstructure : But we should remember, that this is only comparing great things with small to assist our ideas.

When the result of these enquiries is fairly examined, we shall be authorised to infer, that whether we suppose the combustible matter, which is the fuel of the volcanoes, to be contained in mineral veins, or in regular strata, it is exhaustible. The progressive advances of some volcanoes, in a line from the first funnel or crater, is a proof that the fuel is exhaustible ; and, moreover, some few volcanoes have been extinguished. We may also assert of the volcanic fuel, that it is not only limited in quantity and exhaustible, but that it is lodged in very widely different quantities in different places, like all other mineral matter. This observation is sufficiently proved by the different magnitude and extent of different volcanoes, which is the very best proof the subject is capable of, there being no possibility of surveying these treasures of fire.

It is fair and reasonable to suppose, that the volcanic fuel treasured up in Mount *Ætna*, and in the line of progress of that tremendous ancient volcano, has been many thousand times as much as some diminutive volcanoes, which can only be said to exist in a comparatively harmless state, without being of sufficient magnitude or force to do much

much harm. All mineral substances whatever, whether useful or curious, are found, in very widely different quantities, in all the different places we dig for them, or see them basset out, where the superficies of the strata are laid bare by streams of water, or otherwise; and we are confident to assert, that there is the same variety or difference of quantity of volcanic fuel as of other mineral matter. These disquisitions are not the fruit of ingenuity and conjecture: Observation and experience assure us, that it is difficult to set bounds to great and little when applied to the concavities or capacities of mineral veins. We have seen some very small and diminutive, and we have seen others exceeding large and capacious; and there is no room to doubt, that there are others deep down in the bowels of volcanic mountains, which are prodigiously larger and more capacious than any that we see or penetrate in our diminutive mole-like operations and researches.

I suppose that new volcanoes will occasion but weak and harmless earthquakes, because there is not as yet extensive excavations made for the reception of copious vapours; however, in process of time, the continual consumption of the volcanic fuel will soon make room enough to contain a sufficiency to push out

streams of lava, or, by quick explosions, to throw quantities of rubbish high up into the air.

The inflammable vapour in coal mines frequently does this last in miniature. The encrease and dilatation of a great cloud of steam lodged behind a quantity of liquid fire or melted matter, will forcibly propel and thrust it out through the mouth of the crater. There is no room to suspect the propelling force of steam and rarified air in any direction whatever, it being the action of fire; and the more it is confined, the more powerfully it will act. If once it collects in force behind any quantity of lava, or other matter, it will violently push it out at the old, or burst a new passage. We are enabled to conceive a tolerable idea of the prodigious extent and capacity of the excavations of old volcanoes from the quantities of matter ejected out of them.

Where we see countries overspread with lava for many miles in extent, and to a vast depth, and know, that besides the lava, immense quantities of pumice, ashes, and other rubbish, have been thrown out in different ages, we must conclude, that the volcanic excavations are large and extensive, in proportion to the quantities of matter ejected out of them; and moreover, when the original site of volcanoes are near the sea, perhaps we cannot guess at one half of the matter ejected, because immense quantities of it have
been

been thrown into the sea, where it lies buried in the waters out of our sight. However, we see enough of it to assure us, that the excavations below are of monstrous extent and capacity; and I have no doubt that this is the reason or cause of the earthquakes of old volcanoes being so extensive, and so dreadfully mischievous in their effects, even at a great distance from the original site and crater; such, for instance, as the late earthquakes in Sicily and Calabria. I dwell the longer upon these abstruse disquisitions, with intention to endeavour, by every means, and by every explanation in my power, to impress upon the minds of all those who read these papers, an apprehension of the great danger of inhabiting volcanic ground, and especially every where in the line of an old volcano. The dreadful catastrophes which have so frequently happened in Sicily, Calabria, Peru, Jamaica, and many other parts of the world, are but too sure proofs of this danger; but there is, in many instances, a sort of infatuation in mankind. We are apt to overlook and forget our danger when the cause of it lies out of sight. I have, in these disquisitions, endeavoured to explain, and to expose the causes of danger; and as far as my knowledge and powers of description will reach, I have endeavoured to make the danger visible to the mental eye, to the end that those concerned
may

may flee from it, at least, with their cities, seaports, and manufactories, and leave the volcanic ground for the purposes of husbandry only. I have before hinted at the parallelism of the veins which contain the volcanic fuel ; and although there should be several of them running parallel to one another, so as to constitute a line of considerable breadth, they will nevertheless still continue their parallelism ; that is, they will continue to run or trend parallel to one another, and to the bearing of the strata.

It is certainly the greatest temerity imaginable, to think of dwelling immediately above such pits of destruction ; into which thousands have fallen almost in our sight, and thousands more will fall into them, if these matters are not seriously and timeously taken into consideration, and put in practice by the philosophic and legislative powers of those countries, and it must be done by their united force ; for such great and salutary improvements are never set about and accomplished without their joint exertions ; and although these disquisitions are rustic, they are not trivial. Their intention is to point out the danger, and the means of escaping it, and the better that all branches of natural history are understood, the better we are enabled in all cases to provide for our convenience and safety ; and it appears to me rational to suppose, that improve-

ment

ments and advances in the knowledge of the natural history of volcanoes, should prove the means of mitigating the evil consequences of them. Accurate knowledge of the cause of any evil, is generally considered as the first means of preventing its effects; and I think this observation particularly applicable to the subject of our present enquiries; and I humbly hope, that the above will not be thought improper hints for laying the foundation of improvements in the natural history of volcanoes.

I might now proceed in my enquiries, and attempt to investigate the original cause of the first beginning of volcanoes; but as the subject is both difficult and mysterious, and appears to me merely curious, I will not spend much time in disquisitions that can be of little or no utility as far as I yet know. It is very well known, that there are various quantities of the vitriolic, and other pyrites in all countries; and these pyrites are sometimes found pure and unmixed, and sometimes blended with other fossil substances. The pyrites are frequently found between the fides, and in the concavities of mineral veins, in very widely different quantities, and in different degrees of purity or of mixture. The pyrites are also frequently found in very different quantities, imbedded in masses and plates, &c. of various sizes, in the strata of coal, and in many of the stony

stony and argillaceous strata which accompany coal; and moreover, it is sometimes found combined with, but concealed in invisible particles, throughout the whole stratum and mass of the coal, in such quantities as frequently to raise a fermentation, when such coal is worked, and parcels of it laid down in any place that is accessible to the common air; and this fermentation first raises some heat, which is by degrees increased, until at last the heaps of coal are ignited by it; and several large parcels of coal here in Scotland have been in a conflagration, and actually consumed, by the fermentation of the pyrites; as, for instance, at Ayr, and at Brora in Sutherland. We know, and have seen parcels of the pyrites fermenting alone to the degree of ignition, when they have been thrown aside above ground; however, I will not assert, that such parcels were perfectly free from particles of coal adhering to some of the masses of pyrites.

Whether the fermentation of pyrites alone, or of sulphur and iron, or any others of the semi-metals, are adapted by nature for kindling and feeding the fire of volcanoes, or whether it is not necessary that there should be some bituminous or oily matter to increase and feed the flame, I will not pretend to determine. Perhaps other inflammable substances are also necessary at first to light and feed the flame; and such, to my

my certain knowledge, are frequently mixed in lesser or greater quantities with various strata, and are found lodged in mineral veins. Petroleum is widely diffused through the Mineral Kingdom; and it is so plentifully combined or mixed with the substance of many species of stones and other fossils, as to cause them to flame strongly in the fire, though not to consume; and in many parts of the world, the petroleum is in such abundance as to issue out to the surface of the ground in great quantities.

There is a species of remarkably pure and fine coal, of a particularly rich and fat quality, deposited in the concavities of mineral veins, which I myself have seen in several parts of the Highlands of Scotland. The greatest quantity of this coal is to be seen at Castleleod in Ross-shire, where some of the veins have been opened and tried, and the coal found to be of an uncommonly rich and fine quality; a particular account of which I gave before in my natural history of coal.

The nature and situation of this species of coal is extraordinary, and quite out of the course of common experience, being found in the concavities of rake-veins, or perpendicular mineral fissures; whereas, other fossil coal is always found in regular strata. I only saw this coal in very small quantity of a few inches thick, in every
place

place where I discovered it, excepting at Castleleod, where, in some of the bellies, pipes, or swellings of the veins, it was up to three or four feet.

Now, this brief sketch may suggest to us, at least a probability, that besides the immense stores of pyrites which are supposed to be lodged at first in the bowels of volcanic mountains, there may also be lesser or greater quantities of petroleum, or of a species of fossil coal, as at Castleleod in the Highlands of Scotland, or of some other combustible matter, either mixed and blended with the pyrites in the same veins, or deposited so near to one another, as that the combustibles would at first be readily ignited by the fermentation of the pyrites; and they may afterwards continue to the end reciprocally to inflame and consume one another. As I have seen different quantities of fossil coal in the cavities of mineral veins in several parts of the Highlands of Scotland, it cannot be called a stretch of vague conjecture to suppose, that the same, or some other inflammable substance may be deposited in the volcanic mountains, though the fact cannot be ascertained; because the superficial parts of the volcanic fuel is there all consumed away long ago. We may form several conjectures how a volcano is at first ignited; as, by elementary fire, or great and uncommon flashes
of

of lightning kindling some easily inflammable substance, or of such flashes of elementary fire kindling dry and parched vegetables, and the conflagrations of these vegetables communicating fire to the superficies of a vein of some combustible fossil substance. With respect to this last conjecture, it may be observed, that the principal crater of many of the ancient volcanoes, is situated higher up on the mountain than any vegetation is ever found ; and as to the first, the inflammable fossils, especially such of them as partake of the nature of coal, are not so readily inflammable as to be ignited by a sudden transient flash of elementary fire ; and, therefore, the most probable conjecture in my opinion is this : viz. That volcanoes are, at first ignited by pyrites at the surface.

Moderate humidity, and the contact or action of the external air, has a great tendency to excite and encrease the fermentation of pyrites ; and it is observable, that the summits of most volcanic mountains are covered with snow the greatest part of the year, and we cannot imagine a situation where the fermentation of these substances would be more powerfully excited than beneath the snow ; and in lower situations, which are not often covered with snow, we may suppose, that the minerals have been sufficiently moistened by long and heavy rains, or by a copious spray from

the sea. But after all that I have said, or perhaps that can be said upon this mysterious subject, I may not exactly hit the mark. I do not pretend positively to assert any thing. All that I can do is, to point out several observations and facts, and leave the reader to form a judgment of them for himself. My own opinion of the origin or ignition of volcanoes is this: I observed above, that accumulated mineral veins are found in some mining countries, where a number of nearly perpendicular fissures meet and join in one common center, from which they spread out like radii to different distances from the central conjunction. Now I suppose, that there was one of these accumulated veins in each volcanic mountain; that the central part of the vein came up to the day at or near the summit of the mountain; that this vein contained pyrites, perhaps mixed with other inflammable combustible fossils; that the rains, and especially the snows, excited these inflammable mineral substances to such a degree of fermentation, as to be at last ignited; and that, when they were once set a-going, the fire would first prey upon the shaft or central column of the vein, which of course would form in time a vast perpendicular cavity, resembling the inside of a prodigious tower, without floors or stories, or the inside of a glass-house. Some of these accumulated

ted veins of vast magnitude have been seen and explored in the practice of mining, and in cavernous mountains.

Now, as these concentrating veins are seen of different degrees of magnitude, it is agreeable to analogy and experience to suppose, that deep down in the bowels of volcanic mountains, these veins have opened and expanded to degrees of wideness and capacity far exceeding any thing we have seen, and that they have been replenished with volcanic fuel. Upon this hypothesis, the first great excavation of a volcano should be much in the form of an irregular conical shaft, the crater being the mouth of the shaft, the extent of which is sometimes seen ; but we can say nothing about the depth, dimensions, and capacity of these volcanic shafts below out of our sight. But whatever the extent and capacity of them may be deep down in the bowels of the mountains, this account of them presents to us the idea of a strong arched figure, like a glass-house, every part of which is well supported upon its own basis ; and I am fully convinced, that this subterraneous form is the real cause or reason why those mountains do not fall down into the immense gulphs and excavations below. In the progress of the volcanic conflagrations, some of the diverging rays or branches of the accumulated vein will communicate with veins of another description,

description, which trend in a line parallel to the bearing of the strata ; and as the volcanic fuel is the prevailing mineral substance or substances of that district, the parallel veins will likewise be replenished with volcanic fuel ; and therefore, in process of time, the volcanic fire will prey upon these veins, and advance in a horizontal direction ; and when these excavations are become extensive and capacious, they also become dangerous and destructive, as at Messina, Calabria, Jamaica, &c.

Some noted volcanoes, such as those of Iceland, not only emit great quantities of steam, but they also throw out great quantities of hot water high up into the air several times every day. We presume, that the natural cause of this phenomenon is a subterranean river, and a thin partition wall of rock interposed between the river and the volcano. This partition wall must be a species of fire-stone, perhaps basalts, some of the varieties of which is the best fire-stone that we know of ; that is, it stands the heat of a furnace, or any other hot fire, better than any other of our hard stone ; and we are told, that basaltine rocks abound in Iceland, and especially in the neighbourhood of the volcanoes, and that the apertures, through which the hot water is ejected there, are in rocks of basalts. This partition wall being heated to different degrees, may produce the different phenomena

nomena and ejections of the water and steam; and, moreover, in some of them, there may be a passage or gap below, in what may be called the banks of the river, over which the water may run sometimes, and fall down into the volcano, which may be the cause of its raging more furiously, and of ejecting the water, &c. with more force and violence than ordinary.

I will now proceed with some disquisitions concerning volcanoes, which are not of so serious a nature, nor so interesting as part of the foregoing disquisitions, being such as have more regard to truth than utility. One of the principal motives which induced me to write any thing concerning the mineral kingdom was, to attempt to obviate errors, and to set the world right in many particulars, and also to lay the foundation, and give a clue to assist young naturalists in the study of this important branch of natural history.

I saw, that false facts and absurd conclusions from them were daily imposed upon the world; and as I knew this, I could not justify myself without detecting such errors, and communicating my knowledge of a great many facts which have been misrepresented by several eminent writers, who have neither taken the pains, nor had the opportunities of seeing so much of the mineral kingdom as I have; and some of them are too much attached to a favourite system to acknowledge truth,

truth, if they saw her adorned with all her excellencies and lucid beauties. How far I have succeeded in this part of my plan and intention, must be determined by the judgment of the candid naturalist.

When gross mistakes and absurd conclusions are published by men of eminence in the republic of letters, as indubitable facts, they have very pernicious effects, by encreasing difficulties in the knowledge of nature, and establishing scepticism; and, by the sanction of great names, such erroneous opinions become the vogue; and, therefore, every novice will say something on that side of the question, although he knows very little about the matter.

I have thoroughly investigated and made myself master of every thing I represent as fact. I wish that all the modern writers about the concerns of the mineral kingdom had done so likewise.

There are two fossil bodies, which are claimed by many, as only belonging to volcanoes, namely *basalts* and *tufa*, which really and truly belong to the mineral kingdom in general. These I will endeavour to rescue from this unjust detention, and to restore them to their proper stations in the system of nature. Because basalts is often found about volcanic mountains, they produce this circumstance as a proof of its being chrystallized by the fire of the volcano; but I affirm,
that

that real basalt is a real stone, and part of a real stratum, the exterior parts of which are frequently formed into columnar and glebous figures, which happened at first by drying.

However, I will not pretend to say, that some of the curious gentlemen, who carefully examine volcanoes, may not see some fragments of basaltine rocks which have fallen from the summit or sides to the bottom of a crater, which may be thrown out again by eruptions of the volcano, with real marks of fire on them; notwithstanding, this accident does not alter the nature of things. Real basalt is still a real stone, which belongs to a very numerous and a very extensive class of strata, the natural history of which I have so fully explained formerly, that little or nothing more need be said about it here; only we may safely and fairly observe in general, that the modern gentlemen of the Pyrrhonian system are as famous for drawing inferences from a shallow knowledge of their subject, when treating of the mineral kingdom, as any set of philosophers that ever appeared in the world.

I have made it evident to ocular demonstration, that the basalts are as much, and as really rocks and strata, as any rocks and strata in the superficies of our globe; and as such, they constitute a considerable material part in the constitution of this great fabric, having as regular

gular strata above and below them, as any we behold in the superficies of the globe, and the basaltine strata spread as wide, and stretch as far in the longitudinal line of bearing, as any of their concomitant strata; and therefore, we cannot allow their being called lava, any more than the other strata found above and below the basalts; and if some of them, namely, the strata of coal, were to come in contact with burning or running hot lava, they would soon make such a conflagration in that part of the globe, as would produce more lava, not like basalts, but like dirty flags, such as we have seen where seams of coal have been accidentally set on fire. The basalts, as I hinted before, is a real stone, composed of different grains and particles of other stones, such as principally of quartz and shirl, with some admixture of iron and mica, and less or more earth, according to the perfection or debased quality of the stone.

Now, the quartz and shirl approach in their natural state to a chrystaline stone, that is, they have the fineness and purity of chrystal; and although quartz is found of several colours, and shirl, as far as I know, always black, yet, nevertheless, they both produce the finest transparent uncoloured chrystal when vitrified, unless there is some mineral admixture to colour it. In short, basalts is found, by chemical experiments, and by every

every other examination; to be as really and truly a stone, as any other rock in the world. But I need not proceed. The strata of basaltine rocks keeping their stations in the superficies of our globe in every country where they are found; their spreading as wide, and stretching and dipping down as far as the concomitant strata which are placed above and below them; and strata of coal being found and wrought both mediately and immediately above the strata of basalts, is as satisfactory and convincing as a thousand demonstrations, to prove that basalts is not lava, nor chrystalized from a fusion by fire, but strata of rock; and which strata of rock bear a considerable bulk, and are regularly placed among the several other strata which form the stupendous structure of the solid superficies of our globe; and if any man doubts the truth of this assertion, he may see it with his eyes in the neighbourhood of Bo-nefs, and in many places among the hills upon both sides of the road betwixt Bo-nefs and Bathgate, almost all over Fife, and in several other parts of Scotland; and moreover, there are as regular and as beautiful columnar basalts in the Bathgate hills, particularly at Hillhouse lime-quarry, a mile south of Linlithgow, as can be found in any country, with strata of coal and of limestone above and below the stratum of columnar basalts; and this is not a

singular phenomenon in this country, strata of basalts being very common in the coal-fields of the Lothians, Fife, Ayr-shire, &c. and they are frequently found in extensive strata in their proper stations, among their concomitants, in the north of Scotland, where there is no coal; which facts are conclusive, and prove beyond a doubt, that basalt is as real, and almost as extensive strata of rock, as any other in the construction of the superficies of our globe.

I will now make some enquiries concerning *tufa*, which our modern naturalists say is only produced by the volcanic fires, which I deny. But in order to point out the true origin, and to illustrate the natural history of *tufa* or *tofus*, it may be proper for me to take a cursory view of some of the stallaetital productions, which are so near of kin to the tufa's, that they are originally of the same family; and it is pretty generally known, that the stallaetites are stony concretions.

That water percollates the pores, and passes through the fissures of the strata, is a truth well known to all fossilists; and it is as well known, that water carries various particles along in its subterraneous motion. While this subterraneous water is excluded from the external air, it continues to carry about the terrene particles that are combined or mixed with it; but when it issues
out

out into the external air, or into any cavern or subterraneous receptacle into which air has access, then the quantity of water is immediately lessened by evaporation, and of consequence, it must drop some of the minute fossil particles and leave them behind. So long as the subterraneous water is excluded from the action of the external air, it may be so perfectly combined with various heterogeneous particles, as to appear to be nothing but a pure transparent liquid, although it contains a considerable quantity of earthy matter. "When air, says Lord Kames, comes in contact with water, it proves a solvent," and melts it down to steam, or particles small enough to rise buoyant in the atmosphere, which doctrine is certainly true; and I think this as clear and evident as any thing of the kind can be, and it helps to explain the process of nature in forming petrifications, concretions, and some species of sediment, especially those of the ochreous kinds.

If water was always to remain in equal quantity and force as when it took up the terrene particles in its subterraneous passage, it would leave none of them behind: They would all be carried forward to the sea. But the contrary is the fact: The water is in part dissolved into particles inconceivably small, or evaporated, and the stony particles are left behind in caverns, &c.
which

which particles form, by the gradual accretion of matter, the stallactites, and other stony concretions. I have seen old deserted mines and coal-works contain great quantities of these productions; and in some places, they form in much less time than I imagined before I saw it with my own eyes.

A great many subterraneous caverns are replenished with great quantities of these stony concretions; among which, the caves of Nigg, at the sea side, a little way to the east of the entrance into the bay of Cromarty, are not the least remarkable. All the stallactites in those caves are calcareous, and of a very fine texture. Either some corroding waters passing through beds of lime dissolve part of it, or else common water percollating the pores and crannies of the strata, finds the lime by the way in small particles, which it carries along; but when the water issues out of the roof and sides of such caverns, the water is evaporated slowly, by coming in contact with the air in the cave, and the stony particles are left behind, and lay the foundation of these curious stallactital productions, which are still enlarging and improving by the continual accretion of matter; that is, by the minute particles which are carried and left by the water. While the stony matter is in a fluid state, before the water has quite deserted it, it is spread out
slowly

slowly by the remaining water, over all parts of the mass actually forming, and then the residue of the water evaporates slowly, and leaves the stony matter there upon the mass, by which process all those several bodies of stone are formed; that is, all the petrifications and stony concretions are formed, and gradually come to perfection, by this secret process of nature. The greatest and most material difference between these concretions and those of another quality is this: All the stallaçtital bodies in the caves of Nigg, and many others which I have seen, are composed of calcareous particles, which will effervesce with acids, and produce lime when calcined. The other concretions are formed by the same process of nature, of vitrifiable particles, which will not effervesce with acids, nor produce lime by calcination, but are easily vitrified or melted to glass or slag.

The caves of Nigg proved to me a most amusing and instructing scene. I found there some of the stallaçtites formed so very hard and perfect, that a blow with a strong stick made no impression upon it. It was as white as alabaster, and of so fine a texture, as to be capable of receiving a good polish. Upon trying other parcels I found, that the pick had a little impression upon some, that it easily pierced others, and I could thrust my finger into some of the masses, although

although they had much the same external appearance as the hardest. In short, I could there trace petrification or concretion in all its stages. I saw some no thicker than cream, and again some of the consistence of milk, and high up towards the roof, I perceived some as thin as whey, the water there being only a little coloured, and could distinctly discern it thickening, as it came gliding slowly down the sides of the cave; which was an ocular proof that the water evaporates by degrees, and leaves the stony matter thus to inspissate, and at last to become as hard as marble.

It evidently appears, to the conviction of our senses, that a small and a diminishing quantity of water suits this process best. Were all the water which issues out of the roofs of caves in many places to continue in full force, and none of it to evaporate, it would carry all the terrene particles away with it in a stream, out at the mouth of the cave. There are a number of antique grotesque figures thus formed in the caves of Nigg, and no ballustrades or organ-pipes ever appeared so magnificent as the stalactital pipes and columns I saw there, and in many other places.

There are great quantities of the concreted substance called *tufa* in many parts of Scotland, in high and low lands, north and south. Tufa is always found upon the surface of the earth, unless it should happen by accident that some adventitious

tious cover is thrown above it. It is commonly situated below some small, flow, or weak springs, and it generally appears in a whitish or ashen-grey coloured, porey, and moderately light marle-like substance, frequently spread out pretty wide and high, resembling at a distance some whitish misshapen rocks. I have seen much of this concreted substance wet, spungy, and soft as mud, while the water which lodged the particles was partly mixed with it before the water had time to be completely evaporated; and I have seen it dried and indurated to various degrees of hardness, and profitably burnt for lime. The process of nature, in the formation of this tophic substance, is to be explained upon the same principles as the stalactites. A small rill or quantity of water issuing out to the surface of the ground, and carrying stony particles with it, part of the water is immediately evaporated so soon as it comes in contact with the external air. By this evaporation, the rill of water is continually diminishing as it advances forward from the aperture out of which it issues, and creeps among the grass along the surface of the earth; and consequently the stream is weakened in its career, retarded in its motion, and some of the stony particles are at first lodged in the grass or otherwise; and when these first lodged particles are accumulated to any thing of a considerable mass of tufa, there becomes

becomes at last little or no run of water at all, it being detained in the chaotic mass of the forming matter. A considerable part of the most recent sediment frequently remains for some time wet, soft, and spongy, like mud, in which all the water that strains out of the ground or rock is absorbed and detained, until it has time to be evaporated by degrees, and the concreted mass to acquire firmness and consistence. I have frequently seen tufa forming immediately beneath the side of lime-rocks, where the quantity of water was so small, as only to slide gently down the rock, without forming a rill; and where the water issued out in such quantity, as to form a rill or streamlet at the foot of the rock, I have seen the mass of tufa accumulated high and wide, and stretching to a great distance below the rock; and it is worthy to be remarked, that where the rill of water issuing out of a lime-rock, or elsewhere, is so strong and copious, summer and winter, as to be able to carry all the stony particles away with it in a full collected current, no mass of tufa shall be accumulated in such places; but the bottom and sides of the rill, or channel of the little current, is generally covered with a whitish crust, by some of the stony particles sticking to every thing as they pass along.

A novice in the natural history of fossils, may at first sight doubt the truth of the assertion, that
 Stalactites

stallactites and tufa have the same origin and efficient cause, from seeing a very distinguishable difference in the internal and external appearance of the masses of both kinds ; and I confess, that the difference of the inner and outer appearance of the masses of both is abundantly obvious ; and, therefore, for the satisfaction of such, I will explain the natural reason of this apparent difference.

I observed before, in general, that this difference in appearance is occasioned by the different situations where they are formed ; but I must be more particular and explicit.

Below ground, the stallactites in caverns are generally found hanging pendulous attached to the roof, or adhering to the sides of the cave, or formed upon the floor, by drops of water falling directly down from the roof. In that situation, the water generally issues out in very small quantity ; and in its descent from above, it glides gently and smoothly down the surfaces of the masses which are forming. The exhalation or evaporation of the water goes on but slowly in that situation, there being perhaps little air admitted, and that little comparatively damp and ineffectual for want of free circulation ; of consequence, the particles of matter, which are very small, can be laid on the encreasing mass but leisurely, and, the water still gliding down, lays these small par-

ticles close together upon the mass, and keeps the surface of it continually as smooth and glossy as if it was polished. In the formation of tufa upon the surface of the earth, the evaporation and waste of the water, on the contrary, is more copious and hasty, being exposed to the external air and sun; and, of consequence, the terrene particles are precipitated more hastily, and in much greater abundance; and these particles, which are large, are more rudely propelled and huddled together into an irregular confused mass, which swells and gorges in different parts, by the remains of the water being detained in it, as in snow in a rainy day, which of consequence must produce a loose porey mishapen mass of petrification. When one quarter of the general mass of tufa is grown high and extensive, by the stagnating and gorging of the water in passing through the newly precipitated stony matter, as formerly mentioned, the water then turns aside from some part of it, and immediately begins to make an addition to the bulk of the accumulated mass upon the side it now runs to, in the same manner as above-mentioned; and then that part of the mass which the water has newly left, gets time to dry and harden, by degrees, as the water is strained and evaporated out of it. I have seen some parts of large masses of tufa, which were high above the present course of the water,

water, dried and indurated to such a degree, as to make them difficult to be quarried for burning to lime, although such parts, when first formed, or rather while forming, were nothing better than a puddle of calcareous mud, much resembling half snow half water in a rainy thaw; and I have frequently wet my feet in both of them.

I think, that I have been abundantly explicit in unfolding the natural history of the stallaçites, and of the tufa, and therefore, I will now proceed and point out some few of the many places where I have seen the tufa; but I cannot now distinctly remember, perhaps, not one in a hundred of the particular spots where I have really seen it. There is some tufa beneath a spring in the Hill of Carlops, about twelve miles south of Edinburgh, upon the north-east side of the hill, and pretty high up.

I have a faint remembrance of having seen tufa in the hill of the farm of Carlops, and I went lately there in order to ascertain the fact, and I saw it about a quarter of mile above the Bridge of Carlops, upon the south side of the rivulet. It is remarkable of the tufa at Carlops, that some of it contains a considerable quantity of moss and grass, which has been enveloped by the stony particles, and it is preserved in the masses of the tufa so perfectly, as to look like petrified moss, which makes

makes this tufa the more curious, and worth the examination of the young naturalist. There is a great quantity of moss upon that mountain, thro' which the water of the spring creeps, and leaves the terrene particles behind in dry weather, which forms tufa among the moss; but the side of the hill is so steep, and the current of the spring so rapid, in wet weather, that a great deal of tufa is then swept down the hill to the rivulet, and especially when the snow is melting. These circumstances, with the strength of the spring, prevent the tufa from greatly accumulating, which it certainly would if the situation was more favourable. There was much more of it twenty-five years ago than there is at present.

There is a quantity of tufa near Troup, in Aberdeenshire, situated near a lime-kiln between the house of Troup and the village of Gardenstoun.

I have seen tufa in the island of Isla in several places, particularly near the south or south-east of the limestone field in that island, where I distinctly remember to have seen one very large parcel of it accumulated like large mishapen rocks. Now, it cannot be pretended, that there are any volcanic symptoms near either of these places. It is a particular loss to these local remarks, that when I saw tufa in the greatest number of places, I had no view of ever having occasion to point out to the

the public such a common natural production ; otherwise I could have enriched this page with perhaps more than threescore ; and I could have pointed them out as distinctly as the above-mentioned three ; but as the very identical spots do not now occur to my memory, I will give nothing from uncertain guess or conjecture.

Having now pointed out and explained the true origin and nature of tufa, the application of what I have advanced about it to the subject in question is plain and simple. It is abundantly evident, even to the slightest enquirer into these matters, that the tufa has no more connection with, nor relation to volcanoes, than to any other place where calcareous or other particles of stony matter exist, and are so situated, that they can be taken up and carried along by water, either into subterraneous caverns, or out to the surface of the ground.

Tufa may be found upon a volcanic mountain, in the near neighbourhood of a volcano, or of volcanic matter, as well as in any other place, where stony particles may be found and carried by water. Rain water and melted snow, percolating the strata of a volcanic mountain, and issuing out of any part of the sides or bottom of the mountain, may bring particles of stony matter out with it, and so tufa may be formed at the bottom or upon the sides of such a mountain. And again, the rain water and melted snow passing through

through the pores and crevices of the strata of a volcanic mountain, and falling down into the excavations of the volcano, may form tufa within the concavities of the mountain, if the water is combined with stony matter ; and it is to be supposed, that the water will find plenty of it in passing through such extensive rocks as those of a large volcanic mountain.

If we look attentively into this matter, we can easily imagine the inside or excavations of a volcanic mountain to be a plenteous repository of tufa, where it is formed in greater abundance, and far more expeditiously, than it possibly can be formed any where upon the surface of the earth. Some of those mountains are known to have been volcanoes for two or three thousand years, and the quantity of lava and other rubbish thrown out of them by different eruptions is immense. Now, the depth and extent of the excavations of those mountains, must be in proportion to the quantities of matter ejected out of them. Upon some of these mountains, a prodigious depth of lava, ashes, and other rubbish, is spread out for several miles from the crater, and other apertures, out of which the several descriptions of volcanic matter are ejected : What prodigious excavations of consequence must there be within the bowels of such mountains ! I am persuaded, that the firey caverns of some volcanoes
are

are much deeper, and extend much further from the original craters than we generally imagine. The extent of the excavated caverns, or their distance from the apertures, must be in proportion to the accumulated or diffused state of the veins of pyrites, or other volcanic fuel. The narrower and more confined these veins are, the further from the crater the subterraneous excavations must extend, to produce such immense quantities of lava, and other rubbish, which has been thrown out of them.

It is well known to mineralists, that the pyrites, and other inflammable fossils, are oftener found in veins and strata, of no great thickness, than in vast accumulated heaps; but these straight veins and strata frequently extend far in the line of bearing; and this great length of the veins is the physical cause of some volcanoes advancing so far in the horizontal line, from the bottom of the original funnel, as sometimes to pass under the waters of the sea from the main land to an island, or *vice versa*, and from one island to another; and it is the cause of eruptions sometimes in the waters of the sea, when a vein or stratum of volcanic fuel happens to come up too near the surface of the solids, under the water of the sea. And, moreover, this is the real cause of many volcanoes lasting so long as they do. If the whole store of volcanic fuel was accumulated contiguous

ous to the first volcanic aperture, the conflagration would be amazingly great and violent while it lasted ; but it would soon consume all the fuel, though ever so great in quantity ; but, according to the real constitution of things, or, in other words, according to the natural history of the mineral kingdom, a vein or veins, a stratum or strata of combustible matter, not many feet in thickness, may feed the interior fires for several thousand years ; but then it is necessary, that the fire makes very extensive progress downwards, and in the line of bearing from the first crater of the volcano.

Now, it is easy to conceive, that this prodigious extent of excavation and length, of course, must cut and intersect a great number of subterraneous springs and currents of water, which will let down a vast quantity of water into the several caverns and receptacles of the volcano.

In some places, not only large and copious springs, but even considerable rivulets, are drained by the progressive advancing of volcanoes, and every drop of the water so drained from the surface, must go down into the excavations of the volcano. It is well known, that water, in its natural state, contains a considerable quantity of earthy, stony, or saline matter, &c. and the dried springs, rain water, and melted snow, percolating the pores, and passing through the crevices of the
strata

strata of a volcanic district, must carry down very much stony matter with it into the various parts of the excavations, by which means great quantities of tufa will be formed or produced, in a comparatively short time, by the immense heat of the volcano evaporating the water to steam almost as fast as it falls down. It is certain, that every drop of that water is evaporated, and goes off in steam; and, of consequence, the stony particles carried down by the water will be left behind, of which various quantities of tufa are formed in different places. When the heat of the volcano is great, the water will be evaporated, and fly off in steam with great rapidity; and, of consequence, as the stony particles cannot be evaporated, the subterraneous tufa will form with equal rapidity, and no doubt successive eruptions will sweep it out through the crater and other apertures, and lay it somewhere or other upon the face of the country in the neighbourhood of the volcano. It may be objected to me, that, in my history of the stalactites, I represented that those petrifications only are formed in subterraneous caverns, but that tufa is not formed there, but above ground, which is true of ordinary caverns; but the volcanic excavations are not ordinary caverns. In the cool receptacles of the mountains or cavernous shores of the ocean, the progress in the formation of stalactites is exceeding slow, because

evaporation is exceeding flow, on account of the small quantity of air that is admitted there, and on account of the dampness and tardy motion of that small quantity ; whereas, on the contrary, in the volcanic caverns the quantity must be greater, a thousand times hotter, and, of consequence, in a thousand times quicker circulation, owing to the outrageous heat ; and the great heat and quick circulation or motion of the internal air, will occasion a prodigious quick evaporation, and of course the terrene particles must be huddled together very hastily, and left loose and porous in the form of tufa, resembling in texture a mass of wet lump-sugar or half melted snow ; and as it is hastily formed in the cavities of the volcano, so may it be as hastily thrown out to the surface by different eruptions, and in the form of “ liquid mud,” as it is called ; at the same time I am confident, that it was not the first matter that issued from Vesuvius, nor from any other volcano, although it might either issue out, or be ejected many times afterwards, when the excavations of the volcano became capacious and extensive enough to let down sufficient quantities of water for producing it. I might point out a great many ways how tufa may be formed in the neighbourhood of volcanoes, and yet it might happen to be produced in many other forms and situations, which I would not be able to conceive nor explain,

explain, without investigating circumstances upon the spot ; but I do not think it necessary to say any more about the matter, as I imagine, that what I have advanced in explanation of the natural history of tufa, will be abundantly satisfactory to convince the unprejudiced naturalist, that tufa has no more to do with volcanoes than with any other places, where terrene particles and water may be combined together, and afterwards either fall into the volcanic excavation, or issue out to the surface of the ground, in situations favourable for the production of that petrified concrete.

From what has been said it evidently appears, that the tufa is not a sufficiently solid foundation upon which to build any part of an hypothesis respecting the eternity or duration of the world, it being an adventitious substance, much of which is a recent production, and which is continually forming, and it will continue to be formed so long as the world endures in its present condition ; and, therefore, it is not necessary after this for naturalists to carry the idea of volcanoes, or volcanic matter, in their heads, when they see tufa ; as it evidently appears, that it has no manner of relation to volcanoes, any more than to other places, which are favourably situated for its production. It is to be seen formed, and now forming, in ten thousand places upon the face of the earth, far enough from volcanoes, or from any volcanic

volcanic matter. Tufa is to be seen formed and forming in at least a thousand different places in Great Britain ; and there is no real symptom of a volcano ever having been within this island.

Perhaps some of these systematic gentlemen, who generally call in every thing to countenance a favourite hypothesis, may imagine, and they have asserted, that they see tufa beneath some of the real strata of the native rock ; but they should be a little more cautious than they often are of asserting too boldly what they are not sure of. Tufa may be found at the foot of a rock, and attached to it, and if there was any original cavern or variety, it may be filled up with tufa ; but it is never found between real and regular strata ; and these gentlemen should remember, that there is such a degree of resemblance between some beds of clay, and of marl, and other argillaceous strata, and also between some of the mineral soils, ochres, &c. and the tufa, as may be readily mistaken by such gentlemen as have not had opportunities of much accurate observation, and long experience, in matters relating to the mineral kingdom.

That fossil substance found upon or near the surface of the ground, called *puzzollano*, may happen to be subterranean tufa, composed of calcareous and ferruginous particles, burnt to a great degree in the furnace of a volcano, before it was
thrown

thrown out by violent eruptions ; and the great degree of heat it then suffered, with the mixture of iron it contains, may be the cause of the absorbent quality which it is known to possess ; but as I am not very well acquainted with the puzzolano, I will say no more about it.

In this æra of learning and science, the inquisitive spirit of research, with philosophy in her company, traverse the bounds of the universe in pursuit of knowledge, and new discoveries are daily made ; and all the tribute of praise and acknowledgment which the warmest gratitude can express, is due to many modern names, for the numerous local observations, and the many facts which have been communicated to the world relating to physics and antiquity, since the commencement of the eighteenth century. But it must grieve a benevolent man, who has more regard to truth than to system, when he sees so many men of learning and worth strenuously endeavouring to found and support a system of falsehood, absurdity, and nonsense, in opposition to the phenomena of heaven and earth, and in flat contradiction to the opinion and belief of sober reason and sound philosophy in all nations, from Socrates to Sir Robert Boyle :—I might say, from the beginning of the world until now. Several modern philosophers may justly be termed innovators in physics and chronology.

They

They pretend to prove to a demonstration, that the world itself is of a much older date than the earliest accounts which are handed down to us from all antiquity, written or traditional; and some of them will allow it no beginning at all, for no other good reason that I know of, but because they did not see the beginning of it. I will relate one pretended fact, which has been lately discovered and made use of, to overthrow the chronology of the Pentateuch, and indeed, all ancient chronology whatever; which fact, is said to be well attested. It is related in Brydon's tour through Sicily and Malta, which I will give in his own words:

“When we came near the sea in the neighbourhood of Catania, I was desirous to see what form the lava had assumed in meeting with the water. I went to examine it, and found it drove back the waves for upwards of a mile, and had formed a large black high promontory, where before it was deep water. This lava, I imagined, from its barrenness, for it is as yet covered with a very scanty soil, had run from the mountain but a few years ago; but was surprised to be informed by Signor Recupero, the historiographer of *Ætna*, that this very lava is mentioned by Diodorus Siculus to have burst from *Ætna*, in the time of the second Punic war, when Syracuse was besieged by the Romans.—A detachment was sent from Tauraminium to the relief of the besieged.

They

They were stopt in their march by this stream of lava, which had reached to the sea before their arrival at the foot of the mountain, and entirely cut off their passage, and obliged them to return by the back of *Ætna*, upwards of an hundred miles about. His authority for this, he tells me, was taken from inscriptions from Roman monuments found in this lava, and that it was well ascertained by many of the old Sicilian authors.

“ Now, as this was about two thousand years ago, one would have imagined, if lava have a regular progress in becoming fertile fields, that this must long ago have become at least arable. This, however, is not the case; and it is as yet only covered with a very scanty vegetation, being incapable either of producing corn or vines. There are, indeed, pretty large trees growing in the crevices, which are full of a very rich earth; but, in all probability, it will be some hundred years yet before there is enough of this to render it of any use to the proprietors.”

“ Near to a vault which is now thirty feet below ground, and has probably been a burial-place, there is a draw-well, where there are several strata of lavas, with earth to a considerable thickness over the surface of each stratum. *Recupero* has made use of this as an argument to prove the vast antiquity of the eruptions of this mountain. For if it requires two thousand years
or

or upwards to form but a scanty soil on the surface of a lava, there must have been more than that space of time betwixt each of the eruptions that has formed these strata. But what shall we say to a pit they sunk near to Jaci of a great depth. They pierced through seven distinct lavas, one over the other, the surfaces of which were parallel, and most of them covered with a thick bed of fine rich earth. Now, says he, the eruption that formed the lowest of these lavas, if we may be allowed to reason from analogy, must have flowed from the mountain at least fourteen thousand years ago."

I will not pretend to dispute the date when the promontory was formed by the lava, nor do I question the authenticity and exactness of the experiment of the pit. I give the same credit to both which I do to other historical facts; but I have several things to observe concerning the conclusions drawn from those facts.

In the first place, I would ask the gentleman who was present at digging the pit, if he is certain that the lava did decay at all, so as to be converted into soil? I think the case very doubtful, especially if the lava was perfect or thoroughly vitrified; and their finding such a number of strata of soil and lava alternately, makes it still more doubtful.

Is it well ascertained, that the surface of a stratum of lava decays and moulders down before the center? If they say it is, I then ask how they came by this certainty? Is it by observation and experience? If it is, then it must happen within a much shorter period of time than the one laid down to calculate the age of the world by, as no men in these ages live up to two hundred years.

For my part, I have some reason, from my own observation, to doubt the outside of lava decaying before the inside. I saw the ruins of several ancient vitrified forts in the Highlands of Scotland, situate upon the level summits of small hills of the breccia. There was a section made, a few years ago, quite through one of those singular forts, beginning without all the ruins, and digging to the rock, and keeping down to the solid rock, until they came to the vitrified wall that surrounds the level area upon the top of the hill, which was the area of the fort. They continued the cut to the rock through that wall, through the middle of the area of the fort, and through the opposite wall.

There was also a section made half way thro' an out-work, which defended the principal access to the fort. The person who attended the cutting of those sections, was as inquisitive as the Sicilian gentlemen possibly could be; and he noted down every discovery and observation he made

upon the spot. I need not observe that the ruins of those forts have a near resemblance to lava, and in fact are lava; the whole wall being vitrified and run together by the force of fire into coarse glass or lava.

Now, it is a fact worthy remarking in this place, that in making the sections above-mentioned, the parts of the lava or vitrification which were most exposed to the external air, were by far the hardest, in so much, that in going through the ruins of the south wall, where large fragments were exposed to the air without any manner of cover, the workmen could not break some of them; but were obliged to roll them out along the trench with levers, until they tumbled over the brow of the hill; and they were obliged to dig a passage under one fragment, which was too large to be removed, and leave it like a bridge over the cut; on the contrary, the north wall, though much deeper and broader than the south, was nevertheless much easier dug through; it being covered with rubbish, which had fallen upon it from a row of houses built within the fort against this wall. The north wall had been as well vitrified as the south to the full; yet was it easier cut through, being covered from the external air. The vitrified ruins of the houses which had been reared against the north wall facing the south, were still more decayed.

cayed than the wall, so as to be easily broken to pieces, and they were buried much deeper under rubbish and earth. The ruin of the north wall was about fourteen feet high or deep, of clean vitrified matter, and very broad, the top of the wall being fallen down ; but the ruin of the out-work was about twenty-four feet high, though all was fallen in and crushed together. This great heap of ruins produced some vitrified fragments on the out-sides ; but when they entered a little way in with their section, they soon found more, which increased as they advanced, and before they were one third of the way through, there was nothing found but vitrified ruins from top to bottom, except about a foot of soil and rubbish which lay above the whole. As they advanced in with the cut, they met with many large fragments, which had been fully as well vitrified as any part of the walls ; they were, nevertheless, all very easily broken, and those which were high up fell to pieces with their own weight, when they tumbled down. Now, in all these experiments, it was found, that the more the lava of those extraordinary ruins was covered from the external air, the more it was found in decay. The one end of the hill, which was the site of this fort, ended in a narrow ridge, upon which there was the ruin of a long narrow out-work, stretching in a right line from the fort. This never

never had been above eight or ten feet broad. There is the clearest vestigia of their having a draw-bridge about the middle of it. There is a gap in the ruin, and a ditch in the ground where the bridge has been, to prevent access past the bridge to the surrounding wall of the fort. It is natural to reflect, that as this wall or out-work was so narrow, much of it would be exposed to the air, and all the changes of the weather, which is pretty severe in that country; it being situate about two miles west of Dingwall in Ross-shire, and about nine hundred feet of altitude above the valley immediately at the foot of the hill.

Now, it is remarkable, that this narrow out-work, though most of all exposed to the air, is still more entire than any other part of the ruins, which corroborates the foregoing observations, and increases the doubt of the lava of volcanoes decaying first at the surface. And moreover, I saw one of these curious ruins within two miles of Inverness, where there had been an outer and an inner fort all vitrified.

The inner surrounding wall, which has been by much the highest, is now nothing but a heap of rubbish mixed with vitrid fragments. The outer wall, on the contrary, never was high, and of consequence, not so apt to tumble down by its own weight in length of time; of course,

it

it would continue to be exposed to the air and weather, and there is now some part of this wall standing entire upon the bare rock where it was first founded. I look upon this entire piece of the remains of these extraordinary ruins as one of the greatest curiosities in Europe.

There was a pamphlet wrote some time ago, containing fundry observations about the discovery of those ancient remains; and from traditions picked up, it is supposed in the pamphlet, that the one near Dingwall was the ancient Selma so often celebrated in Ossian's Poems. Be that as it will, these ruins are certainly very ancient. It is near two thousand years since the Romans landed first in Britain, after which period, there was no occasion for such extraordinary shifts in cementing strong walls, as the use of lime in building was about that time introduced into the island.

These observations about the remains and fragments of the vitrified forts, certainly make it exceeding doubtful whether the lava of volcanoes moulder first at the surface; and their finding strata of lava between the strata of soil, makes it more doubtful. I cannot help thinking what I have said sufficient to stagger the faith of the unprejudiced in the conclusions drawn from the observations made in Sicily; and the observations concerning the lava of the vitrified forts, are as
real

real facts as the Sicilian ; and, as they are at home, the truth of them can be more easily examined.

But we need not proceed. It is well known to all those who are in the least acquainted with the history of volcanoes, that prodigious showers of ashes are frequently thrown out of the craters, and sometimes to a great distance, which produces a stratum of good soil at once, and as effectually in less than twoscore, as in two thousand years ; and this fact is as well known to the gentlemen of the new system as to any others in the world, although in this instance they chuse to conceal part of their knowledge, which is particularly faulty in such plain, simple, and obvious facts, which invalidates the truth of all they advance, and tumbles the whole fabric of their system at once to the ground. That ashes, pumice, and other rubbish, are very frequently thrown out of volcanoes, and spread wide over the face of the country, is too commonly known to admit of any dispute, and certainly these showers of ashes will fall upon beds of lava, as well as upon any other part of the country ; and as the contiguous parts of the country next the volcano are generally covered with lava, the showers of rubbish and ashes have a greater chance to fall upon lava than upon any other ground. I made it evident before, that tufa is formed very expeditiously in
the

the excavations of volcanoes ; and I have all the reason in the world to believe, that there is a proportion of tufa in these showers of ashes.

There is no room to doubt of there being tufa mixt with the ashes, and this mixture will greatly enrich the composition, and hasten its melioration into good soil. Now, the situation of the above-mentioned promontory is not so favourable for acquiring a thick coat of soil in so short a space of time. Its distance and site may not be convenient for receiving showers of ashes and rubbish ; and moreover, a promontory is such a windy situation, that every thing is blown off rather than on to it. I have myself seen the soil evidently decreasing upon some promontories in Britain, and mostly all blown off the farther end of several in Aberdeenshire, Caithness, &c. But I need not multiply words. It is obvious to every unprejudiced enquirer who will examine circumstances, that there might be a greater depth of soil made upon the one place in less than twoscore of years, than upon the other in much more than two thousand. When I look seriously into this subject, I cannot help admiring the credulity of these gentlemen in building so high upon such an insufficient foundation. Some of these celebrated facts are founded upon single local circumstances, are but slightly attested, and it is impossible to prove the truth of the conclusions. They are founded upon hypo-
thesis

thesis alone ; and, moreover, the fact I hinted at before of showers, of ashes, &c. mixed with tufa, overthrows the hypothesis, and makes all their reasonings upon it chimerical and absurd. It is highly probable, that the boasted experiments or pits were made on purpose to countenance an established persuasion. I care not what name or figure any one of these gentlemen bears in the world. He is a man, and so am I, and as such I am as deeply interested, as an individual, in all the concerns of this world, and that which is to come, as he is ; and, therefore, I have a right to examine the truth of what he proposes to me upon so interesting a subject, and to detect the fallacy of his propositions, if it is in my power, and I think it my duty so to do.

In this freedom of enquiry, I will venture to suggest, that if any man, or number of men, were to take the history of the experiments upon the lava in their hands, and to go to the spot, and dig a hundred pits through all the strata of it, I doubt if their discoveries shall correspond with the history, or come any thing near it ; no, not in one single place out of the hundred ; and the reason is plain and obvious. Volcanoes, with their eruptions and lava, are not regular operations of nature, but dreadful accidents, attended with the most horrible confusion and disorder. It is an indubitable fact, attested by a multitude of
unprejudiced

unprejudiced eye-witnesses, that eruptions of volcanoes are sometimes exploded with such amazing violence, as to force a prodigious quantity of matter high up into the air ; and, at other times, these astonishing explosions throw the matter many miles off into the sea, or on to the land, which frequently makes shocking havock and devastation.

When lava issues out, it is attended in its appearance and consequences with still greater horror and destruction. Fields, woods, stone-walls, farm-houses, and populous towns, are all driven before it, or whelmed under it with irresistible force and destruction. In such horrible confusion, it is impossible to ascertain the numberless accidents that may happen. All the vegetable and combustible substances that come in contact with the fire, will be consumed at once ; but the upper soil of the destroyed fields will be driven before the prodigious weight of the fiery deluge, and thrown this way and that, at all possible uncertainty where or how. Some parcels of it may be inclosed or overwhelmed betwixt layers of burning matter, and other parcels of it may be surrounded by meeting currents of fluid fire, and form little islands or nests of soil, which will be overflowed and buried by the next deluge of fire that issues out, perhaps that very day, or the next, or the next year. And will any sober man pretend

to draw important inferences from such horrible devastations and utter confusion as this, and call them well attested facts? Their credulity appears to me as astonishing as the confusion upon which they build their inferences, if they really are deceived themselves by such false lights; but if they are not, why then the gentlemen are pleased to divert themselves with our ignorance and credulity. To think them serious, is but a very poor compliment to their penetration and philosophy. But I take up too much time in exposing such vague and fallacious conclusions. It is fully evident from what has been said before, as well as from some parts of their own histories of volcanoes, that the phenomena which they discover, and build upon, might all happen within fourteen hundred years, as well as in fourteen thousand years twice told.

Singular Observations and Improvements.

THE fifteenth century is remarkable for having produced some of the greatest events that ever were recorded in the History of the World. The foundation of a great revolution was laid in Europe, which, in its consequences, relieved millions from a double slavery, and procured for them

them not only civil liberty, but also the liberty of the mind, which had long been kept in darkness, bound fast in the cruel shackles of an imperious usurping tyrannical priest, whose galling yoke depressed the spirits and marred the prosperity of almost all Europe, and who aimed at enslaving and oppressing all nations. The way to the East Indies by the Cape of Good Hope was discovered, which roused the attention and enlarged the ideas of a people who had newly knocked off their fetters: A new spring was given to commerce, and all the States of Europe were enriched thereby. But the greatest and most wonderful of all the events which that century produced, was the discovery of a new world by Columbus, nearly equal to the old in magnitude, and in many places exceeding the old world in fertility, and the excellence of its productions.

The question how America was first peopled has been long bandied about among the learned and inquisitive, and the world has been favoured with many strained conjectures to explain that difficulty. Among the great number of conjectures which have been started upon this puzzling question, some have come pretty near the truth, though none as yet have explained the point in a satisfactory manner. I have not the least doubt that the Old and New Continents are joined together; that America was first peopled by the north;

north ; and that the first inhabitants of it, man and beast, walked there by land.

But it may be objected to me, that supposing the two Continents are joined together, and that there is firm land all the way. Allowing this to be true, there still remain insurmountable difficulties in the way. The frozen regions of the north are impassable. Mountains of ice and frozen snow are there heaped upon mountains of ice and frozen snow, until they are piled up into the higher regions of the atmosphere, and more is still accumulating, which renders that way absolutely inaccessible to man or beast.

I will readily grant, that the north has long been impassable, and, I am confident, that it will continue to be so to the end ; but at the same time I will assert, that there was a period of time when this passage was clear and open. The world itself, and every thing in it, had a beginning ; of consequence the mountains of frozen snow had a beginning ; and, before that beginning, the passage by the north was clear.

There were then neither mountains of ice nor snow ; and before the mountains of ice and snow began to accumulate, America was, or might be, peopled by land from the Old Continent.

It is not so easy to prove when the mountains of ice and snow began, as that they really had a beginning. The last proposition is self-evident ;
but

but it is difficult to point out the beginning of that accumulation. It is more than probable, that in the early ages after the flood, the frost and snow of winter would dissolve and melt away in summer, even near the poles, as it does now in more temperate climates. In the course of time, some little would remain all summer upon the highest mountains, which might continue to increase for ages, before it entirely ceased thawing in the valleys and lower grounds every summer. It is well known by experience, in the vicinity of high mountains, that the remains of frozen snow have a great and sensible effect upon the climate of the countries near the snow; and that while the snow remains upon the mountains, the air continues cold and chilly, even in summer, and vegetation advances but slowly. From this experienced fact, it is obvious to reason, that the gradual increase of the frozen snow in the northern regions, would likewise affect those climates by degrees, until at length it would become extremely cold through the whole length of summer; and this gradual increase of snow, and the consequent increase of the coldness of the climate, would by degrees prepare matters for a final change. The worse the climate grew, the harder and severer the winters; and the colder the winter, the more snow would remain over summer; and at last, an uncommonly

monly severe winter would pour down such a prodigious quantity of snow, that the ensuing summer could not melt and dissolve it away off the lower grounds; and then the foundation of those prodigious mountains of ice and frozen snow was laid, which have been accumulating ever since; and it is impossible for us to judge of the height and extent of this accumulation. Before the beginning of these accumulated masses of snow, the passage by the north, between the two continents, was clear and open, but now it is shut up for ever; and it is highly probable, that this event happened in an early age after the flood; which, in my opinion, helps to account for the Americans forgetting their origin, and being forgotten by the people of the Old Continent.

It is observable, that the Americans in general have but very little notion of society and government; and that they are very ignorant of the manners and customs of the Old Continent: However, it is not at all wonderful to find them ignorant of our manners and customs, when we reflect that their emigration was so very remote. We must suppose that they suffered many and severe hardships at first; and perhaps they might have been reduced very low before they discovered and settled in the milder climates, and more fertile parts of America; and nothing in
the

the world has a greater tendency to reduce mankind to a state of savage rusticity, than great and insufferable hardships.

With respect to the comparatively more cultivated state of society, and the fragments of knowledge found among the people of Mexico and Peru, it is probable, that they were obliged to some of the ancient Britons for their superior degrees of knowledge and improvement. It is recorded in the history of the ancient Britons of Wales, and recognized by the great Lord Lyttleton in his historical works, that about six hundred years ago, Madoc, the brother of the reigning Prince, being well skilled in navigation, and having some difference with his brother and Sovereign, equipt a ship, and sailed westward in quest of discoveries: That he discovered land, and after informing himself of the nature of the country, he came back to Britain, fitted out six ships, and sailed away the second time, with a numerous colony of men and women, but was never more heard of.

When this historical fact is impartially examined, it seems to throw a gleam of light upon the history of that country, and to account for the advanced state of society and civilization in Mexico and Peru, while all other parts of that immense continent were found in a state of savage rusticity. I am of opinion, that the continent

nent of America was peopled at first from the north-east of Asia. The copper colour and thin beards of the people of East Asia, and of America, seem to favour this conjecture. We are told that the native Americans have no beards. Now, a very thin beard is the next thing to none at all; and perhaps, the food and climate of the Americans, and their manner of living in general, might, in the course of time, have the effect of increasing a natural imperfection, until by degrees it arrived at the extremity of no beard at all. But however that might be, there is great reason to believe, that the continent of America is joined to the north-east of Asia. A very great number of attempts have been made, for near two centuries back, by many of the best navigators in the world, to find out a north-west, or a north-east passage to India, but all in vain hitherto. The attempts to discover a north-east passage have been innumerable, by the ships of almost all the nations of Europe; but they were all repulsed in pushing north-eastward, either by land, or by ice and shallow soundings, which is much the same thing, as shallow water is seldom found far from land. This great point is now fully decided beyond a doubt, By the justly celebrated Captain Cook, and by his successor Captain Clerk, who both of them sought a passage from the west and north side of the continent of America

America to the Atlantic ocean ; but they were equally unsuccessful with the attempts from the south and east sides of that continent. Captain Cook traversed the west and north-west coast of America, from the back of Canada, in the north latitude 44. to the northern extremity of that continent ; and along the north-east coast of the continent of America, to where it joins the continent of Asia, south-west of Kamschatka ; and he every where found evident and convincing marks of that part of America being a great and extensive continent. About the north latitude 59. he found an immense river, up which he sailed above two hundred and ten miles ; and saw, that it came from a vast continent which, in those latitudes, was wholly covered with snow down to the sea-beach, in the months of June and July. It is very well known, that such magnificent rivers as this are never found upon narrow slips of land, but always derive their sources off the extensive surfaces of great continents.

This great and worthy navigator, and his successor, Captain Clerk, carefully examined the north eastern coast of America, where it joins the Continent of Asia, to the west or south-west of Kamschatka ; and they saw with certainty, that the two Continents were joined together in one continued firm land.

When Captain Cook came to the coast of Asia, he sailed a good way in sight of the north-east coast of that part of the Old Continent, and then he sailed westward again to the coast of America; and he sailed along the north-east coast of the New Continent, until he was fully satisfied that it joined the Old; and when he could proceed no further with the ships up a narrow inlet and shoal water between the two Continents, he “dispatched Lieutenant King, with two boats well manned and armed, to make such a search as might tend to ascertain the point with certainty.”

Lieutenant King was out two days, and he tells us, that “the crews of the boats rowed without intermission towards the land till one o’clock the next morning, when Mr King, upon his landing, ascended the heights, from which he could see the two coasts join, and that the inlet terminated in a small creek or river, before which there were banks of sands or mud, and in every part shoal water. The land for some distance towards the north was low and swampy; then it rose in hills; and the perfect junction of these on each side of the inlet was traced without the least difficulty. From the elevated situation in which Mr King took his survey of the sound, he could discern many spacious valleys, with rivers flowing through them, well wooded, and bounded by hills of a moderate

moderate height. One of the rivers towards the north-west seemed to be very considerable; and he was inclined to suppose from its direction, that it discharged itself into the sea at the head of the bay. To this inlet Captain Cook gave the name of Norton's Sound, in honour of Sir Fletcher Norton, now Lord Grantley, a near relation of Mr King." This inlet is situated in about 70 degrees of north latitude, and about 190 of east longitude.

See page 225. of the Abridgement of Captain Cook's last Voyage.

To the above extract I will beg leave to add another paragraph from page 270. of the same book. When enumerating Captain Cook's discoveries, the writer says, "His third and last voyage, however, is distinguished above the rest, by the extent and importance of its discoveries. Not to mention the several smaller islands in the Pacific Ocean, he discovered the group, called the Sandwich Islands, which, on account of their situation and productions, may perhaps become an object of more consequence than any other discovery in the South Seas. He explored what had before remained unknown of the western coasts of America, an extent of three thousand seven hundred miles; ascertained the proximity of the two Continents of Asia and America; sailed through the straits between them; and surveyed

surveyed the coasts on each side, so far as to be satisfied of the impracticability of a passage in that hemisphere from the Atlantic into the Pacific Ocean, by an eastern or a western course. He has, in short, completed the hydrography of the habitable globe, if we except the Japanese Archipelago, and the sea of Ameer, which are still imperfectly known by Europeans."

No man was ever better qualified for researches of this nature than Captain Cook. No man had ever more experience nor equal success in these researches; nor could any man be more faithful, inquisitive, and attentive to all circumstances than he was; and, therefore, his account of these things is always to be relied on with absolute confidence.

But to return to the consideration of the improvements of Mexico and Peru, it appears to me very probable, that Prince Madoc discovered Mexico in his first voyage: That he began to instruct the Mexicans in the rudiments of agriculture, building, weaving, of the use and comfort of apparel, and of the advantages of society, and the regulations of government. He could not at first communicate his ideas to them in words, for want of an interpreter; and, therefore, he was under the necessity of making use of signs, and it is pretty certain, that he would be obliged to delineate some of his thoughts upon
paper,

paper, if he had any, or upon linen, or some other flat surface, before he could be understood by them; and this may be the origin of the art, which the Mexicans were masters of, when the Spaniards first landed there, of painting upon cotton cloth the intelligence sent in their dispatches to the Emperor of Montezuma, instead of writing them, which they could not, having no knowledge of letters.

Madoc might have no women with him in his first voyage. When he had considered the nature and the wants of the country, he would see the necessity of having European cattle, corn, iron, artists, and many other articles, to lay the foundation of a lasting and a comfortable colony; and, moreover, he would have a laudable ambition and a benevolent desire to carry over some of his relations and best friends to partake with him the happiness and glory which he expected to enjoy in the fine country, which he had the honour of discovering, and which he meant to improve and civilize. When Madoc came back to Britain, he might leave two or three of his men behind him, to assist the Mexicans in carrying on the improvements which he had begun, until he returned with a colony, and European materials, and conveniencies.

Madoc came back to Britain, fitted out six ships, and sailed away for America the second time

time, with a numerous colony of men and women, but was never more heard of.

Misfortunes and disappointments have blasted the towering prospects and apparently well-founded hopes of multitudes, not only of the sanguine and imprudent, but also of the most wise, the most cautious, and best of men, in all ages and countries. Though Madoc was successful in his first voyage, he certainly was unfortunate in the second. There is great reason to suppose, that he was overtaken by a storm from the north in his second voyage, which would drive him to the coast of Brazil, or some other part of South America, where his little fleet was wrecked, and all his sanguine views, and well concerted plans, were overwhelmed in the waves, and none but himself and his wife, and perhaps two or three men, were saved. It has been observed by those who first explored South America after the Spanish invasion, that here and there a person more fair and white than ordinary was seen among the wandering copper-coloured hordes. If any of the Britons escaped from the devouring deep, and reached land in their boats, or otherwise, after their ships were cast away, the savages would kill the men, and save the women on account of their beauty and novelty; and this may be the origin of the few fair people seen in South America.

Madoc

Madoc would save himself, his wife, and the few who were with him in the boat, either by keeping off from the land at first, or by flying timeously from danger. The wreck of his fleet might happen in sight of, or not far from the great river of Amazons. When he discovered the immense opening of the mouth of that river, the largest in the world, which is fifty leagues wide where it enters the ocean, he would naturally imagine it to be an arm of the sea, which communicated with the gulph of Mexico; and, therefore, he would boldly enter it, and sail and row up the stream until he reached the Lake Llauricoch, out of which a navigable branch of that river issues; and this lake is but a short distance from Cusco and Lima, the ancient and modern capitals of the empire of Peru. When the Spaniards first conquered this great and wealthy empire, they were informed by the natives, that about four hundred years before the arrival of the Spaniards, a man and woman of majestic form, and cloathed in decent garments, appeared to them all at once upon the borders of a lake, who declared that they were the children of the Sun, sent by their benevolent parent to reclaim and instruct mankind, and to lead them in the way to happiness. The period of time fixed by the Peruvians for the first appearance of the founders of their empire, corresponds exactly with

with the time of the emigration of Prince Madoc and his company. Madoc was undoubtedly obliged at first to use signs in Peru, as well as in Mexico, to make himself understood. He might point to the sun as the chief guide he made use of, by his observations, to lead him to their country, from which the Peruvians might infer, that these strangers, who afterwards proved so worthy of their high regard and veneration, were the children of that glorious luminary, of whose benevolent and powerful influences their country enjoyed so large a share. Or, perhaps, Madoc might judge this to be a proper political fiction to engage and fix the attention of the savages he was to collect and rule, as it were under the immediate eye and daily cognizance of a powerful visible god. The benevolence of the Peruvian emperors in general, the flourishing and happy state of society through the whole extent of that great empire, when Pizarro the Spaniard invaded it, are clear proofs of the wise institutions established by their benevolent law-giver; but from the accounts of these people given us by the Spaniards, the most superstitious corrupt sect of christians in all Europe, we can form no proper idea, at this distance of time, what theological precepts Manco taught his people.

The Peruvians called this extraordinary pair Manco Capac and Mama Ocello. Manco and
Madoc

Madoc have a likeness of sound, and Mam Ichel is a *high mother* in the ancient British language. But I am perfectly sensible of the uncertainty and fallacy of conjectural etymology, and the similarity of the sound of words, and therefore I will drop that topic. We have more certain and positive proofs, that some wise and benevolent European came among these people, and laid the foundation of the improvements of society, and the happy institutions of their government.

It is said, that the wandering savages of Peru differed but little from wild beasts when Manco first appeared among them, and that he began to collect them together, and to form societies in a hilly country, which was the likest to his own country which he had left, if we suppose him to be Prince Madoc. In sailing up the river of Amazons, he would be made sensible of the putrid damps and unhealthy climate on the banks of that great river. The powerful rays of the sun in the arid valleys of Peru would at first be intolerable to a man just arrived from the cold and rainy mountains of the west coast of Britain, who must of necessity be continually out of doors to teach and lead his people to till the ground, and raise the necessaries of life; and this first choice of his residence is no unfavourable symptom of the wisdom and genius he afterwards discovered in the foundation and improvements of his

empire. Manco first began to teach the Peruvians to till the ground, to raise plenty and variety of food, and to build houses to lodge the different families apart, and screen them from the open air and the changes of weather, with other useful and necessary arts.

Mama Ocello likewise began her truly glorious and benevolent reign in imitation of her husband, and taught the women to spin and weave, and to make garments to clothe their nakedness. When Manco had instructed his people in the necessary arts of social industry, and to raise and preserve plenty of provisions, he then proceeded to form proper laws and regulations of society, suitable to the climate and other circumstances, and to teach his people good morals, the rules of justice and benevolence, the advantages of industry as the source of plenty, and the other social and necessary virtues; and great things are spoken of the civilization, the happy government, and mutual felicity of the Peruvians, throughout their widely extended empire, before the Spaniards came to destroy them; and the Spaniards have proved themselves a cruel nation of murderers, and exterminators of the human race, both in Europe and America. We are told, that the Peruvians divided the year, as we do, into 365 days; that they had some notion of astronomy; that they were acquainted with the points of the horizon,

where

where the sun sets in the summer and winter *solstice*, and in the *equinoxes*; marks which the Spaniards destroyed, as being monuments of Indian superstition; and it has been asserted, that the race of the Incas, who were the descendants of Manco, was whiter than that of the natives of the country, and that many of the Royal Family had beards. All or most of these particulars are European marks; and as Prince Madoc did sail for America the second time, it is more than probable that he and his wife reached the country of Peru, and founded that great and happy empire.

It is very remarkable, that the people, both of Mexico and Peru, were impressed with a strong persuasion, that they were some time or other to be visited by a powerful people from the east. This notion was handed down by tradition from father to son; and the tradition appears to me to have this origin. Madoc left the Mexicans with a promise and full intention of returning to them again; and, therefore, that generation would live in continual expectation of his appearance; but the next generation would only remember what their fathers told them; and the tradition would grow still more dark and uncertain in the course of time. When Madoc landed the second time in South America, and settled in Peru, he would
very

very naturally imagine, that some time or other his countrymen would follow his track.

He could not go back to Britain, having no ship, nor tools and artists to build one; but he would suppose, that the curiosity of the Britons would prompt them to search for America, and he would communicate this thought to his subjects, which undoubtedly is the origin of the tradition in Peru.

Whatever opinions the world may entertain respecting the first peopling of America, here is an historical fact which rationally accounts for the improvements of society and government in the countries of Mexico and Peru, which cannot be contradicted; and, therefore, I am warranted to assert, that this is the most natural and authentic account of the origin of those empires that has been yet offered to the public. But although most of the American tribes seem to derive their remote origin from the north-east of Asia, it is very evident, that the Esquimaux Indians are of a different race. Their aspect, diminutive size, occupations, and manner of living, distinguish them from all the other tribes of America.

But in all these particulars they resemble the inhabitants of Greenland. Bold and intrepid at sea, these little men rush into the stormy ocean of the north, single, in their small canoes, and pursue the herring, the seal, and the whale, in all their

their motions through the polar regions, where other people dare not venture in the stoutest ships, and seldom leave their prey until they conquer and bring it ashore. Though weak, half blind, and imperfect upon land, they attack the whale, the morse, and the seal, at the hazzard of their lives, in the most tempestuous ocean in the world, wound them with their imperfect weapons, and bring them on shore. These people cover the concavity of their little boats with a skin, and make the whole water-tight; and when each man sits down in his canoe, he ties the skin fast about his waist, so that no water can enter; and then he rides like a buoy over the dreadful surges, with his paddle in one hand, and his fish-spear in the other, and surmounts all difficulties, in procuring food from the sea, in a country for ever covered with snow, where the land produces little or nothing.

The Esquimaux eats the flesh of the seal and other fish, and drinks the oil of the whale, which he also burns in a lamp to dress his fish, and to warm his hut, which is generally as hot as a stove.

From these characteristic features of the Esquimaux, they must have derived their origin from Norway or Lapland. The Norwegians have always been, and they still are remarkable for their intrepidity and skill in braving a stormy sea in a small

small boat; and these are the nearest parts of the continent of Europe to Greenland, and Greenland is near the country of the Esquimaux, if not joined to it.

I will resume the consideration of the mountains of ice and frozen snow, after premising a few observations concerning the borders of the ocean.

The proper adjustment or balance of the quantity of the waters of the ocean in all parts of the globe, has been a subject of difficult investigation among the learned for several ages past. Naturalists saw long ago, that several Deltas were formed and forming in all parts of the world; and that the waters upon the borders of the ocean were continually propelled and driven back from the ancient boundaries of the shores, by the new land which is gradually forming; and many weak and silly conjectures have been imposed upon the public, as great philosophical discoveries relating to this subject.

Some philosophers maintain, that the ocean recedes from the land in one place, in consequence of its making encroachments upon the boundaries of the sea in another; and this hypothesis appears to them as an undeniable truth, because they can produce the appearance of some little instances in point; but these apparent instances in proof of their hypothesis are too little, doubtful,

ful, and no way correspondent to the subject. Others will have it, that the water of the ocean is continually growing less and less,—that the surface of the sea, of consequence, is continually falling lower; and, therefore, is continually receding from our European shores. But they give us no satisfactory account what becomes of the water that has left us. However, as an infallible proof of the truth of their hypothesis, they point out to us the ancient sea-marks on land, from whence, say they, the ocean is fallen away.

I will very readily acknowledge, that the marks they shew us were once the borders of the ocean; but that period was in the early ages of the world, before the new land was formed by the spoils of the mountains in such places, between the old and new flood-marks. It appears evident, from the observations which I formerly made, that there have been numerous and extensive tracts of new land formed in the bays, and upon the borders of the ocean in all quarters of the globe, in places formerly possessed by the waters of the sea; and that such new land is continually increasing in lesser or greater degrees. Many millions of acres of new land have been thus formed; and the quantity of water which at first occupied those extensive spaces, must have been very great; of which no good and
rational

rational account has been given as yet, by any naturalist that I know of. This great quantity of water is to be looked for, and to be found in the accumulated mountains of ice and frozen snow, which are continually increasing in the polar regions, and upon the summits of all the very high mountains in the world. I hope, that this account of the matter will not be thought the less satisfactory, because it is new.

If we take the trouble to consider this matter attentively, we shall discover a very exact agreement and correspondence between the cause and the effect, in respect to quantity and time, &c. Immediately after the deluge, there were no accumulated mountains of ice and frozen snow, nor was there any new land formed from the sand and slime carried down by the rivers; but by degrees the new land began to be formed, and by degrees the water began to be lodged in the form of ice and snow in the polar regions, and upon the summits of high mountains. The quantity of new land formed in the bays and sinuses, and at the influx of all the great and little rivers of the world, and other places upon the borders of the ocean, and in all the lakes and marshes which have been filled up in inland places, is immense; and of consequence, the quantity of water which originally occupied those places was immense.

We

We cannot explore the icy mountains of the polar regions ; but when we consider, that annual additions have been laid on for several thousand years, we cannot help supposing it to be of very great extent and depth. Reputable navigators assure us, that they frequently meet with fragments of ice floating near the island of Newfoundland, and other parts of the northern seas, of such prodigious magnitude, that they appear like mountains, some of them being several miles in circumference, and near half a mile of perpendicular depth in the water and out of it. Now, such islands of ice must have broken off by their own weight, perhaps in a warm summer, or in a great storm, from the skirts of prodigious mountains of ice hanging over the sea ; which mountains might have accumulated in a few years, partly upon the sea, and partly upon the land, or perhaps altogether upon the sea, which freezes every season near the poles, and especially in shallow places ; and it is very probable, that some parts of those seas may continue frozen through the whole length of several successive cold summers ; and if so, the alternate showers of sleet and rain in such summers, would penetrate the great depth of snow which fell in winter, and run it altogether into one strong coagulated mass or body of ice.

Such reflections may give us some idea of the polar seas ; but we can form no better idea of the inland places of those dismal regions, than to compare them to the highest terrestrial mountains we know of ; and by reflecting, that additional strata of snow are frequently lodged above one another every year ; and from these considerations, we may assuredly conclude, that the height of these mountains, or in other words, that the depth of the frozen snow must be very great. It appears to me more than probable, that there may be in those regions a depth of several miles of frozen snow in some inland places at a distance from considerable open seas. We cannot suppose it less than several miles in depth, when we reflect upon the vast quantity of snow that falls every year in those regions, and that none of it melts in places remote from the sea. There may be a partial thaw at some chance times for a short space of time upon the coasts of considerable seas ; but far from the coast, the greatest heat that can happen will have no farther effect than to raise a cloud for an hour or two, which will produce a shower of sleet or snow ; and as soon as the whole horizon is overcast, the frost will return, and the former short relaxation will only tend to harden the general mass, and make it more impenetrable.

I have hinted before, that there is an exact coincidence, agreement, and correspondence, in all the parts of nature, which throws light upon the several parts, and enables us to perceive, that they mutually explain and illustrate one another, which makes natural history a pleasant and a profitable study.

I have given some instances of this beautiful correspondence and agreement in the several parts of nature; and I advance what I have said about the polar mountains of ice and frozen snow, as another remarkable instance. Millions of acres of new land are formed from the spoils of the mountains in numberless places upon the borders of the ocean, and by filling up inland lakes and marshes all round the globe. The quantity of water which at first occupied those maritime and inland places must have been immense; and there are millions of acres of ice and frozen snow in the polar regions, and upon the summits of the highest mountains, the extent and depth of which we cannot ascertain; but it is all water, and the quantity is immense. The new land formed by the sediment of the rivers had a beginning, increased gradually, and is still increasing in some slow degree. The accumulated ice and frozen snow had also a beginning, increased by degrees, and is still increasing; so that as the water is propelled back from the shores, by the increase
of

of land from the slime of the rivers, a proportionable quantity falls annually in form of snow in the polar regions, &c. where it is frozen and detained, and by these means a perfect equilibrium is preserved; and therefore, the surface of the ocean is exactly of the same height now as it was three or four thousand years ago, which is absolutely necessary for navigation, and for many other purposes. Was the surface of the sea to fall lower, as many have asserted, our rivers would all become useless for navigation, as we could not enter them from the sea. It would, in that case, be always like our ebb tides, when shallow water, and a strong current, prevents any vessel from entering the rivers.

On the other hand, was the surface of the sea to rise higher in proportion as the water propelled back from the shore into less extent of surface, and as more water has been poured into it from the lakes and marshes which have been filled up, then we should, in a great measure, have been deprived of the benefit of the increase of so much new land; as the sea, by rising so much higher, would overflow a considerable part of it, and of our original valleys. In this case, we should hear daily of nothing but inundations, the sea breaking over its former boundaries, and deluging one part of the world after another, until at last all our belgias, deltas, carses, and low islands,

islands, would be laid under water. But matters are much better ordered by omniscient wisdom for the general good. The superfluous water is lodged at the poles, and upon the summits of the mountains, where it accumulates gradually, in exact proportion as new land increases. Thus, we see that there is an immense magazine of water stowed out of our way at the poles, and upon the high mountains, in situations too cold for the habitation of man or beast, where it is piled up upon the dry land in the form of ice and frozen snow, which has been accumulating from the earliest ages after the flood, and the depth of the masses are still increasing. This metamorphosed liquid is heaped upon the highest mountains, even under the ardent suns of the torrid zone. The Cordilleras, and the Andes in South America, are allowed to be the highest mountains in the world, and these are for ever covered with snow. Neither the extent nor depth of the polar regions can be ascertained, because we cannot explore those dismal regions; but we can go round the base of the Cordilleras, and other high mountains, in the torrid and temperate divisions of the earth, which may enable us to compute the extent of the snow in these quarters of the world; but it is out of our power to find its altitude or depth, because we cannot ascend the summits of many of them, in order to
 examine

examine circumstances. Not only the summits, but the upper regions also, and the hollow divisions of the Cordilleras, and other high mountains, are filled with snow. All the upper regions of very high mountains are so extremely cold, even under the perpendicular rays of the sun, that neither animal nor vegetable can live there. All the upper glens and concavities of such mountains are filled up to a level with the summits, upon which an immense quantity is piled; but to what height above the summits, it is impossible for us to know. The upper regions of the Cordilleras are perpetually immersed and concealed in the gloom of thick and impenetrable clouds, which generally hang pretty low down; and although these clouds frequently rise up so high as to discover the regions of snow, yet the summits are seldom or never seen; but if it happens in some remarkably clear day, that the clouds are entirely dispersed, yet the summits of the mountains are so extraordinarily high, and so far removed from the view of man, that perhaps they are not distinguishable from the apparent void of the etherial regions; and therefore, we have no way of computing the height or depth of the elevated snow in the torrid zone, nor of either the extent or depth in the polar regions.

The only sure data that we have,—the only means that is left us, by which to judge of the quantity

quantity of ice and snow that is lodged in these regions, is to compare it in idea with the quantity of water which has been propelled from the margin of the sea, from the mouths of rivers, and from lakes and marshes where new land has been formed, as the one will exactly correspond with the other. But I need not insist upon this topic.

I have, in my rustic manner, produced such instances as will throw sufficient light upon the subject to establish the fact, and to prove it to the clearest demonstration; and the truth of this part of natural history is a further proof of a position, which has been often recognized in these papers, viz. that all things work together for the general good, in the œconomy of the universe, to accomplish the wise and benevolent intentions of Providence; and when we can discern the clear demonstrations of consummate wisdom and benevolence shining brightly in all parts of nature, then physics or natural philosophy becomes the most delightful of all human studies.

We have now finished these disquisitions, and the result of them is a clear demonstration, that America was at first accessible by land; but that the passage was soon shut up by great falls of snow, which in a short time was frozen so hard, that it has never since been dissolved; and that
this

this snow has been accumulating for about four thousand years past ; that the quantity of water which is congealed in ice and snow in the polar regions, and upon the summits of high mountains, is immensely great ; and yet, notwithstanding the greatness of the quantity of the water thus lodged, the surface of the ocean is not fallen lower by the loss of it, but is now exactly the same height as it was four thousand years ago ; the spaces which at first contained these immense quantities of water being gradually filled up, and occupied by new land formed of the slime of the rivers, which new land has been made upon the borders, and in the bays of the sea, at the mouths of rivers, and in making inland valleys and plains, where lakes and marshes had been before, which keeps the surface of the sea always at the same height : And when this subject is examined, there will be found an exact agreement and correspondence between the quantity of water, which had been evaporated and congealed in ice and snow, to prevent its running down again, and the extent and depth of new land, which has been made in all parts of the earth.

Before I finally dismiss this subject, I will beg leave to offer a few interesting remarks about new-formed slimy land, and then I will conclude, by suggesting some practical observations and improvements, with a view of making such new
land

land more salubrious, and of more use to the interests of society and commerce in all parts of the world.

It is generally known to all philosophers and naturalists, that swamps, morasses, and slimy lands emit crude, putrid, and noxious vapours, which prove fatal to the health and longevity of man, and likewise of several other animals; and there is not the least ground to suspect the truth of this position. The humid putrified vapours of such places teem with myriads, with clouds of various *animalculæ*, which are the source and seeds of pestilential diseases; and these sometimes prove so malignant and destructive, as to sweep away almost all the human race off the face of the adjacent countries; and even when mildest, they are greatly thinned; and those who survive in such unhappy regions of the earth, seldom enjoy a vigorous state of health, but pine away under the pernicious effects of so bad a climate and atmosphere. Perhaps, such slimy new formed lands, and the extensive morasses which are made by the overflowing and stagnations of great rivers, with the putrid dampness which is generated in the shades of thick and extensive woods in warm climates, have had greater and more general effects upon the health and longevity of the human race in all countries, and in all ages of the world, than has been hitherto imagined. It was these causes,

joined to a change of food, and the manner of living in general, that gradually brought down the longevity of the descendants of Noah, in a few generations after the flood, to the present standard.

Moses tells us, that the inhabitants of the antediluvian earth lived up to a very great age, some of them up to near a thousand years; and he also tells us, that there was no rain, that is, no heavy showers in the antediluvian state of the earth; but that a mist arose, which gently descended again, and diffused its humidity in small particles, which watered the face of the ground like our mists and dews. Now, if there was no thick and heavy rain, like our rains, in the antediluvian state of things, of course the rivers and rivulets would not be swelled, nor muddied or discoloured, nor could there be any inundations of the flats, to spread the slime, and form stagnant marshes. A thick mist would gently water the plants, and, but springly, the face of the ground, like our dews, which would never affect the rivers in the least, nor hardly ever produce any run upon the face of the ground, excepting what might fall from the leaves of trees, which would soon be absorbed in the arid soil. Let no man laugh at this as an improbable fiction. From the influence of surrounding causes, which affect the constitution of the atmosphere, it seldom or ne-

ver rains in Egypt; and it certainly never rains
 in the plains of Peru, in South America. A
 thick mist or a dew is all the moisture that falls
 from the atmosphere in these countries. Now,
 why might not the particular causes, which pre-
 vent the fall of rain in some few countries in the
 post-diluvian earth, prevail over all the countries
 which were inhabited before the flood? We fre-
 quently see such mists as prove refreshing to the
 grass and other plants and vegetables; but we al-
 so see, that they have not the least tendency to
 swell or affect either river or rivulet. There is
 a considerable condensation of such mists upon
 the leaves of trees, and upon the mountains and
 higher grounds, in which places the water gently
 and leisurely sinks into the earth to supply and
 maintain the living springs, which are always
 pure and undisturbed, till rain comes to swell the
 currents, and wash away the soil. The antedilu-
 vian mists could only produce scanty springs,
 which would collect into small rivers, and these
 would for ever glide gently along, limpid, smooth,
 and undisturbed to the ocean; and, of conse-
 quence, no new land could be made in the ante-
 diluvian earth. There was then no swelling nor
 overflowing of water, and, of course, the atmos-
 phere would not be suddenly over-charged with
 excessive humidity, nor with crude and pestilen-
 tial vapours. Such a constitution of the elements
 would

would produce an equable and salubrious atmosphere, undisturbed by violent storms, and sudden changes from heat to cold, &c.

Trees and shrubs thus watered, and growing in such an equable and constant temperature of the air, would produce plentiful crops of wholesome well-ripened fruits. But this mode of watering the ground was but very ill adapted to agriculture in general. Such scanty supplies were very disproportionate to the demands of a thirsty soil, and could never give ease and success in tilling the ground for crops of corn and roots, &c. After the most copious dews, the lighter soils would remain quite too dry to produce plentiful crops, and the stiff and stronger soils would be so very hard and bound, that they could not be worked without the greatest difficulty; and when worked, they would not produce much without rain. In short, without showers of rain, such as we are blessed with in summer, to soften, meliorate, and fertilize the soil, comparative sterility would continually distress and frustrate the hopes of the husbandman; and this was really the case; for we are told that the earth was doomed to sterility, to produce "thorns and thistles;" and, when tilled, she was not to yield her strength. Indeed she could not, without softening refreshing showers of rain. The antediluvian Patriarchs groaned under this curse of the hardness and sterility

rility of the earth ; and they had a promise, and entertained a full persuasion, that they would be relieved from this calamity by some great deliverer ; and, agreeable to this hope, when Noah was born, they had a strong presentiment that he was the destined person who was to bring about the happy revolution which they expected ; for they said, “ This same shall comfort us concerning our work and the toil of our hands, because of the ground which the Lord hath cursed.” But they were greatly mistaken with respect to the kind and manner of the deliverance ; for when it was offered them, it appeared worse than the calamity itself, and none would accept of it but Noah and his family. In this Noah was an eminent type of Christ, whom the Jews would not accept, because he did not appear in worldly pomp and grandeur, and propose to deliver them from the Roman yoke, and to raise the Jewish state above all the kingdoms of the world. And the same thing happens every day. All nations worship the god of wealth and of worldly grandeur. But, however stubborn and ungrateful the antediluvian earth might prove to the labours of agriculture, yet a pure, serene, and equable atmosphere, with a diet of milk and vegetables, and the purest streams to drink, promises health and long life, undisturbed by malignant diseases and excruciating pains. In the beginning

ginning of the post-diluvian state of society, there was at first but eight persons in the whole world, and these could, and undoubtedly they did, chuse a situation as like the old world as they could find, where they would enjoy pure air and water, remote from the stagnations of morasses, and the slimy mouths of great rivers. It is recorded, that Noah's Ark grounded upon the mountain of Ararat, which is generally supposed to be a high mountain of Armenia. The country of Armenia is in general either mountainous or hilly, and the hilly parts of that country abound in rivulets, and the small hills and valleys are exceedingly pleasant, healthy, and fruitful. Noah and his sons would settle for some time in this delightful and healthy situation, where he would always breathe a pure salubrious atmosphere, remote from the rank exhalations of the plains and humid morasses, and from the slime, which would be lodged in vast quantity by great rivers. It is also recorded, that immediately after the subsidence of the universal deluge, "Noah began to be an husbandman," and it was necessary that he should. It deserves to be remarked, that this ancient Patriarch always approved himself a worthy man, and a friend to society, by doing all the good that was in his power in every situation. The inhabitants of the antediluvian earth were universally abandoned to extreme and boisterous wickedness.

wickedness. Oppression and violence every where prevailed, and then "Noah was a preacher of righteousness."

The deluge put a dreadful period to the matured wickedness of the old world. The Ark was loaded with the precious treasures which we enjoy; and it saved not only the four families of Noah and his three sons, but also all sorts of cattle, and all sorts of grain and seeds, which would have perished in the waters of the deluge. This was the most precious freight that ever floated on the sea, a depositum committed to the care of Noah, of great consequence to the future welfare of the world. The various grains and other seeds were all committed to a grateful soil, after it had been cultivated and prepared by Noah and his sons; and the produce of his first harvest would give plenty and variety of food. The various productions of a fruitful country, which was now well watered and refreshed with plenteous showers of rain, would soon multiply exceedingly; and this plenty and variety of all things would cut off all shadow of pretence for future oppression and violence; and thus Noah laid the foundation of the virtue and happiness of the new world in general prosperity, and the enjoyment of plenty and variety of all the necessities and comforts of life, as the fruit and the reward of industry.

It

It is to be supposed, that Noah and his descendants would live contiguous for some time among the limpid springs in the dry soil and pure air of the hilly country of Armenia; and it is also to be supposed, that, for some considerable length of time, they would lead a life something similar to what they had been bred with in the old world. They had plenty of milk and vegetables, with the best of fruits and purest water to furnish the same sort of food, which would have very powerful effects in preserving health and lengthening out their lives; and the *stamina* or anciently good habit of body which they brought with them, and still enjoyed, as yet not much affected by any vicissitudes or shocks of the post-diluvian state of the earth, and constitution of the air, would also have a very great influence upon the longevity of the first descendants of Noah; and we are told that many of them lived to a great age. But their lives were soon shortened when they came down to the slimy plains and humid marshes of Shinar, Egypt, &c.

When the descendants of Noah were considerably increased in the countries of Ararat, the good Patriarch would begin to send out colonies first to the land of Shinar or Babylonia, to Egypt, Syria, and Mesopotamia, well knowing that the whole earth was to be peopled by his posterity.

Some

Some imagine that Noah finally settled in China after the deluge, which I think very probable.

It has been the universal experience of all ages and countries, that great prosperity and fulness of all things produce idleness, and idleness a contempt of order, and the regulations of society. Many of the young bucks of the early ages would commence hunters, and hunting is the nurse and alternative of war. These hunters would possess themselves of extensive territories for the convenience of the chase, and the antediluvian violence would begin to make its appearance again. Nimrod very soon began to be a mighty hunter, and a mighty conqueror of extensive countries, out of which he chased the former peaceable inhabitants; “and the beginning of his kingdom was Babel, and Erech, and Accad, and Calneh, in the land of Shinar.” A father of virtuous sensibility, who has devoted his whole life for the good of his family, cannot live happy with vicious and disobedient children. A worthy and aged prince, who has constantly aimed at the good of his people during a long reign, cannot brook the total loss of his authority. When the descendants of Noah began to despise and break through his good regulations of society and government, he might select a few of the most virtuous and docile, and separate himself and his small company from the wickedness of the mult-

titude, which he could no longer controul; and he might travel eastward until he arrived in China, in order to be far enough from the wickedness and violence of the rest of his descendants. Noah was not the only father whose soul has been vexed at the disorders of his family, and filled alternately with indignation and grief at their wickedness!

“Noah began to be an husbandman,” but his grand-children began to be mighty hunters and oppressors of men, which scenes of violence Noah could neither suffer nor remedy; and, therefore, he went as far as he could out of the sight and knowledge of the very same evils which had procured the destruction of the old world, and settled in China, where he had to begin the world anew in his old age. Noah would consider it as a heavy calamity to be forced at that age to wander from a people, for whose happiness he had done so much; but we can seldom discern the good intentions of Providence in our severe afflictions.

Noah was now going to found the most industrious, the best cultivated, the most durable, and most populous empire in the world. The institutions of the laws of China seem to have been founded in agriculture as a broad and solid basis, upon which that extraordinary empire was to be raised, and to flourish through a length of ages, in spite of all the vicissitudes and shocks of

of time, and of barbarous conquerors. Agriculture is no where honoured as in China, where the Emperor himself plows the ground, from which we receive plenty of food, and all sorts of necessaries. Like a good and virtuous father, he gives this best precept and example to his children ; and there never was a period in the annals of the Chinese history, nor in the former ages of tradition, when it was not the custom for the Emperor to hold the plough. No doubt but this was at first an unavoidable condition of the dignity, that the first in power should be first in industry, and then the ruler of the people was always the best ploughman ; and though, in after times, when they became great and wealthy, they began to relax, and at last he only plowed one day in the year, yet they still keep up so much of the ancient custom, as makes husbandry more reputable, and in higher esteem there, than in any country in the world ; and, of consequence, China is far better cultivated, more fruitful, and more populous and wealthy, than any other country upon the face of the earth. This is the fruit of the plans of prosperity and happiness which Noah laid in his old age, which at last proved successful.

In that state of industry and plenty, which was at first established in China, the human race, and all the useful animals, would be as fruitful as their
well

well cultivated country ; and, of consequence, population would make quick advances.

“ Noah lived three hundred and fifty years after the flood ;” so that he had time enough to lay the foundation, and to complete the wise institutions of the Chinese government, supposing him to live in China only the one half of that period of time. But human perfection is never complete, and but of short duration. The seeds of evil are always in our hearts, and they always spring up quickly in the luxurious soil of prosperity. The best laws and wisest regulations of society cannot prevent some from transgressing them. Many of those who are brought up in fulness, and carefully nursed in the lap of prosperity, feel a sort of self-sufficiency, and a dissolute inclination to throw off the yoke of legal restraint and obedience to useful and salutary rules ; and as such would see room enough, and had no experience nor idea of difficulties, some of these young bloods of China would soon set up for themselves, in a full persuasion of arriving at eminence, perhaps at empire, without being confined in the trammels of strict regulations ; and they would easily persuade others to be the companions of their adventurous rashness. But as these would carry the same spirit of licentiousness, and seeds of disorder, along with them wherever they went, there was but small hope of their success

in

in founding useful colonies, and establishing industrious and well regulated societies. These were already tired of the patient and orderly occupations of tilling the ground ; and, therefore, they would soon commence the savage or sylvan life of hunting and fishing, and feeding a few cattle ; and many of them would idly roam about in search of such spontaneous fruits as the woods afforded them. This class of people would degenerate by degrees into absolute rusticity and barbarism, and their immediate offspring would be taught nothing in the world but the use of the bow and of the club. This is the origin of the hordes of wandering Tartars, and even of the Americans, who descended from the north-eastern Tartars ; and this may sufficiently account for the profound ignorance and barbarous state of all the aboriginal sylvan tribes, who live by hunting and fishing.

Our modern philosophers may make a parade of their learning and ingenuity, as long as they please, in building the scale or gradation of the advances of man from the savage to the civilized state, but it is all in their own imaginations and systems ; for man by nature never advances one step towards a civilized state of society and industry ; on the contrary, untutored man, of himself, goes backwards, and degenerates from the civil to the savage state. The Tartars laid the foundation of their perpetual hordes in idleness, ignorance,

ignorance, and savage rusticity; and they have never tilled the ground, nor sought after any useful knowledge, though they know well enough where to find it, being surrounded by civilized nations.

It is a curious amusement to trace out the sedulous labours of a number of modern philosophers, carefully following one another's footsteps in discovering the origin of Man, like the monkey in the woods, and gradually leading him by very slow degrees from the savage or sylvan state to the civilized, when there is no such thing in nature. What a world of knowledge, penetration, and judgment they discover, in tracing out and describing a mock history of what never happened in the world, nor ever will! Man, in a savage state, never, of himself, advances one step towards the civilized, nor never will, without some remarkable revolution, or the application of some powerful external spring or impulse, to persuade or force him to a change of life; and I believe it must be force. Much persuasion and force have been employed to reform the savages of many countries; but it has always been experienced, that so soon as the force of the impulse was removed, which excited any of them to an apparent compliance with the rules of society, whenever the spring was relaxed, they always returned immediately to the savage state and savage

vage life. The various tribes or wandering hordes of Tartars, possess an immensely extensive country of several thousand miles in length from east to west, and of very great breadth, all of it situated in the northern temperate zone; yet those vast regions of the earth have never been cultivated. Though the Tartars have as rich and fertile soils, and as fine climates as any in the world, these fine countries have never been disturbed by the plough nor the spade. So far are these hereditary barbarians from any advances towards a civilized state of improvement and industry, that they burn the luxuriant crops of grass off their fertile plains, when it begins to wither in the latter end of summer; and this barbarous savage practice they continue to this day, because they will not take the trouble to cut and preserve it for their cattle; and they find a fresh growth in spring from the ashes of the last crop, which acts as a rich and powerful manure.

The Tartars are now in the same savage state as they were four thousand years ago. They have frequent communication with the Chinese, Persians, and other civilized nations, and know their manner of living, but they like their own much better; and nothing in the world could persuade them to change their own customs. They prefer a piece of horse's flesh, delicately prepared

pared by animal heat between their own buttocks and the living horse's back, to the best cookery of their neighbours. The native Americans derived their remote origin from the north-east of Tartary, as was clearly proved above, and they still retain much of their original character. Neither precept nor example will induce a North American to submit to the civilized regulations of society and government. He always prefers his own way of life to all others, though he is generally in want of all things, and sees the plenty and variety of the comforts of life which the Europeans enjoy. They still remain perfect Tartars in both continents.

The Caffres, and all the other savage tribes in the south of Africa, are much in the same state as the Tartars and Americans. None of all these savage tribes advance one step towards civilization. Though Chinese, European, and Arabian traffickers, have been a long time among the savage hordes of Asia, Africa, and America, yet none of them have been induced to change their state. The civilized have not been able to reduce the number of savages without killing them. But, on the contrary, the number of savages have been increased in many parts of the world within the ken of history. Several Arabian tribes, who have wandered into the wilds of Africa, have

lost all marks of civilization, and are become as savage and barbarous as the Aboriginal Africans.

Our modern philosophers have really taken the wrong side of the question ; as it is evident, from the annals of the world, and from the nature of things, that man naturally degenerates, and without some powerful impulse to propel and force him forward, he will never advance a step towards civilization.

He has been accustomed to roam about as chance or inclination led him, in search of his food and of his pleasure,—he has always found some sort of subsistence in this state and course of life, and this he likes best, from custom, example, and long habit ; and therefore, he would rather suffer death than be always confined to the laborious cares of husbandry, and be bound by the strict regulations of society. Established habits are not easily eradicated. The civilized philosopher can hardly conquer them ; how then can we expect that the savage will leave his old habits which have taken root for ages ; and especially when he has what he thinks reason on his side, viz. the immemorial example and custom of his ancestors, who have all of them lived in the same manner.

The savage state is from the beginning a state of degeneracy from choice ; and when mankind from choice degenerates to the state of the beasts

that perish, he never will recover from it in any length of time, but will degenerate more and more, and his habits and liking will take deeper root, and increase for ever. His indolence, his independence, and roaming way of life is pleased with it, and the example of his ancestors confirms him in it, and he will be confirmed more and more to eternity, without some remarkable revolution,—some mighty impulse to force or captivate the mind. They like their own state better than any other, and they glory in it, and despise the Europeans, and all others, with all their conveniences and regulations of society. They plead with force of argument and a plausible shew of reason, in favour of their own way of life. They call the civilized man a slave, and express the utmost contempt for his variety of food, his delicate cookery, and splendid furniture, and fly from him to their woods, where they follow their own inclinations; and imagine, that they are not miserable, because they have no relish for social happiness, on account of their powerful and unconquerable aversion to its rules and labours. The Chinese industry, wealth, and splendour, has only attracted the attention of the Tartars to rob them when they were able, but never to follow their example.

The Negroes and Caffres of Africa have not been induced by any means to lay down the bow
and

and take up the spade, since they have had the example of European industry and plenty.

The North American provinces are well cultivated ; and the savages are every day in the cities and villages, where they often taste of the variety and plenty of food which our people enjoy ; and they see that our people are well clothed, well lodged, and enjoy abundance of all things, but the example has no effect.

The savages with joy return to their woods, and consider themselves free men, the only dignified character and happy state in the world, and they look upon our people as miserable degraded wretches ; slaves doomed to work and to obey the will of another, which they consider as worse than death ; and the example of near two hundred years has not altered their opinions in the least.

How vain, then, and futile are the systems of our modern philosophers, about the slow but gradual advances of all nations from the savage to the civilized state ! which notion is now become a canting phrase among the learned, but the real progress is retrograde. Without line upon line, precept upon precept,—without constant instruction and example, with the care and exertions of government and police, man will degenerate from the civilized to the savage state, of which the banditti of all ages and countries is

an irrefragable proof; but man, without some irresistible impulse, never advances a step from the savage to the civilized state. But to return from this digression.

• When the posterity of Noah were so multiplied as to be able to send out many regular colonies, some of these colonies would chuse to settle in rich plains upon the fertile banks of great rivers, in the neighbourhood of morasses, and of the slimy mouths of the rivers, where, by this time, plenty of new land was formed. In these situations they would find the lands easily cultivated, and their crops would be rich and luxuriant, which soon determined them to build cities, to form regulated societies, and at length to found empires in such places; but they had not then philosophy nor experience enough to perceive that they were in the near neighbourhood of death. As the soil of these valleys and well watered plains was rich and fertile, perhaps they would never reflect, that the damp and putrid exhalations of the morasses, and of the slime, was pestilential to the human frame; and yet it is certain, that such situations and countries would grow worse and worse as new land was increased upon the margin of the sea, and by filling up shallow lakes in the course of the rivers. In proportion as new land was formed in the course, and at the mouths of the rivers, the
channels

channels or beds of these rivers would fill up, be straightened, and grow shallower in many places, which would occasion such inundations in the rainy seasons, or after the melting of snow upon the mountains, that many extensive new formed plains would be laid wholly under water; and these inundations would increase the evil, by forming morasses, and leaving a putrid slime upon the face of the ground.

Thick and impenetrable forests would soon overspread extensive countries and districts in the early ages of the world; which would prove plenteous sources of putrid and unwholesome vapours. These multiplied and united causes of sickness and disease, would soon taint the blood, and affect the constitutions of the inhabitants of the valleys and plains, to such a degree as to shorten the former period of life. The inhabitants of the plains would intermarry with those of the hilly countries; and thus, by frequent mixing, they would in the course of time become all one mass. The inhabitants of populous cities would soon grow wealthy by commerce, and then they would learn the arts of luxury. The simple diet of their ancestors would then be changed for animal food and fermented liquors. These several causes collectively would, in the course of four or five hundred years after the flood, make a total change of the constitution of the body of man,

man, and bring it down to the present standard of longevity, which has been very near the same for more than three thousand years past.

The damp, crude, and putrid soil upon the humid plains, in the course of the rivers of the world, and at their influx to the sea; is perhaps the most general and the most durable calamity that ever afflicted the human race; but this great evil always has been, and it still continues to be their own fault. This greatest and most general of all evils might have been made the greatest good in many parts of the world. By proper care, by proper plans of improvement, and well directed industry, millions of acres, which really are the abhorrent nurseries of diseases, pain, and death, where their squalid and pestiferous armies are mustered, and from whence they spread over the face of the earth to torment and consume the children of men, might have been the happy scenes of health, plenty, and vigorous felicity.

Had the kings of armies, and governors of the world, employed but the twentieth part of the people, and of the treasures which they consumed upon unjust and useless conquests, and upon cruel, capricious; and unjust wars,—had they employed them in draining the morasses, in thinning the woods, in improving the beds and the bars of rivers, in giving encouragement to agriculture, and improving the waste lands of their dominions
and

and governments, what a happy world would this have been, in comparison of what it really is, and always has been, from the earliest ages !

All Asia and Africa might have been a rich and delightful garden, like China, swarming with healthful, industrious, and well regulated societies, and teeming with plenty and variety for their subsistence. But man is mad, and seldom studies his true interest, or acts with justice and probity. A capricious fancy—an idle empty whim—a trifling or malevolent intention, takes possession of the whole man, and hurries him forward with impetuosity to commit the strangest absurdities, and the most horrid crimes, through the whole course of his life, without looking back, or asking himself the question, what he is about ? What multitudes of armies, what miriads of the human race, have been led out by such fools and madmen to plow the main, or to force their way through putrid deserts, or over impassable rocks, to be afterwards buried in the pestilential camp, or in the sanguine field of battle !

How I honour and revere the Chinese Legislators—who have shunned war—who have taught their people the arts of peace—who have made their rivers the marts and the commercial roads of communication to all parts of their vast empire—who have made their cities work-shops and granaries, and the whole face of their extended empire,

empire, at once a populous town, a flourishing manufactory, a rich corn field, and a delightful garden ! How widely different are these wise, peaceable, and industrious leaders of mankind from the mad and cruel masters of the world, who have neglected agriculture and all the arts of peace, but have increased the morbid fens with the blood of their own, and their neighbour's subjects.

Holland and China are instances in proof of what other marshy grounds might be made ; and yet it is astonishing to reflect what prodigious extents of the richest soil in the universe is soaking in fetid morasses, or fermenting in the putrid effects of its own fertility, and filling the atmosphere far and wide with sickness, pain, and death, which is carried far upon the wings of every wind.

It is not easy to conceive an adequate idea of the prodigious extent of new land which is formed in the course and near the influx of all the rivers of the world. If we should take a cursory view of the Rhine, and other rivers, which have produced the Netherlands, of the Danube, and other great rivers of Europe, we shall find a considerable extent of new land formed in this least quarter of the globe ; but when we survey the Ganges, Wolga, Indus, Ava, Pegu, Cambodia, Petlho in Nankin, the Oxus, Oby, Euphrates, Tigris,

Tigris, and other great rivers of Asia, which are very numerous, and then join to these the Nile; which has produced most of Lower Egypt, the Senegal, Cuama, Zair, Niger, and other great rivers of Africa, we shall find the quantity and extent of new land formed by them upon the Old Continent to be immense.

Let us, in the next place, cast our eyes over the map of America, and take a view of the rivers Plate, Amazons, St Francis, Torantis, and other great rivers of South America, and of the rivers Mississippi, St Laurence, Oroonoko, North Colorado, Susquehana, Hudson's, Charles's, Delaware, with the other large and very numerous rivers of North America, and we shall be led to believe, that there is as much new land formed by the subsidence of the rivers in the New Continent as in the Old. Some of the mountains of the New Continent are much higher than those of the Old; and it is from the mountains that all the great rivers of the world derive their sources; and it is with the decomposed spoils of the mountains, and higher grounds, which the rivers carry down, that new lands are formed. The rivers of the New Continent are as much larger than those of the Old, as the mountains are higher. The remotest source of the river Plate is two or three thousand miles from its influx. Several of its branches are prodigious rivers, of which the

Paraguay is the chief. They are collected off the surface of a vast extent of country; and when they are all joined together, the Plate is liker a sea than a river, where it falls into the ocean. The river Amazons is still larger than the Plate. It derives some of its numerous sources from the Cordilleras, and some of them from the Andes, which are the highest ranges of mountains in the world. This immense and magnificent river is like a spreading wall-tree, which shoots out a great number of large and strong branches on every side. The principal river, and most of its larger branches, traverse vast and extensive plains, which are frequently laid under water by the united inundations of so many great rivers rushing down from such lofty mountains, situated in the most rainy part of the globe. The river of Amazons is said to be much above three thousand miles in length, to contain a great number of islands in its course, and that it is about a hundred and fifty miles broad where it joins the ocean.

The river Mississippi in North America, though not quite so large as the rivers Plate and Amazons, seems to have a much longer course than either of them, and to collect its streams off as great an extent of surface; but the mountains of North America are not so high as those of South America, which is a very good reason for the

rivers not being quite so large. The remote branches of the Mississippi derive their streams from unfrequented deserts far to the west of Canada, which have never yet been thoroughly explored by any Europeans, so that the real length of this great river cannot be exactly ascertained; but it appears highly probable, that the length of it from the sea to the source of the furthest branch, is not less than four thousand miles.

The great river St Laurence, in North America, seems to be under the same predicament as the Mississippi, with respect to the knowledge and distance of its remotest sources, which are situated somewhere in distant regions to the north-west of Canada, little, or perhaps not all, frequented by Europeans.

The Oroonoko is another vast river of North America, which derives some of its sources from the lofty mountains which are situated under the line between New Granada and Peru. We are informed, that this great river begins to swell in the month of April, and continues to increase during five months, when all the fertile plains upon its banks are laid under water. It is very evident, that the rainy season under the line, and the melting of the snow by the rains, and by the advancing of the sun towards the north, and returning south again over the line during these months, is the cause of these periodical inundations; and the

the inevitable result or consequence of these floods will be, that all the plains and low lands upon the banks of this great river will be slimy, marshy, and unwholesome, during the greatest part of the year, which is a particular misfortune, as most of the lands bordering upon the Oroonoko are said to be remarkably fertile.

From this very cursory view of the great rivers of the world, it appears very evident, that the quantity and extent of new land gradually formed by the sediment of the rivers filling up lakes, and enlarging the shores of the ocean, must be exceeding great.

I am of opinion, that if all the Deltas, all the morasses and humid valleys, and other parcels of new land, were drained and improved to the highest degree they are capable of, they would be abundantly sufficient to maintain as great a number of inhabitants as there are now upon the face of the earth; so that, upon this supposition, the human race now actually existing upon the whole face of the earth might be doubled, and there would be abundant provision for them all; and, therefore, if this supposition is founded in truth, it merits serious enquiry, whether or not the thing is practicable? If there are such immense tracks of the richest soil in the universe lying dormant and useless, what can be more interesting

ing than to know if it is possible to recover all this precious treasure?

Nothing appears to me more evident, than that all or most of it may be recovered and improved to be the most valuable and most commodious land in the world; and, moreover, such improvements would bring health, plenty, and joy to those miserable regions, where sickness, want, and gloomy melancholy now reign uncontrouled from age to age.

When such prodigious tracks of land, in all parts of the world, have been allowed to lie in a marshy and chaotic state hitherto, breeding fetid and pestilential vapours, it may be thought by some, that such places are not improveable, otherwise that such improvements would have been accomplished long ago; and, therefore, they will think that I have been betrayed, by a fondness for the marvellous, to be guilty of a very rash assertion. There have been such great works undertaken and accomplished in ancient times in many parts of the world; these have been the wonder of all succeeding ages; and, therefore, it is not to be supposed, that the improvements above suggested are impracticable, otherwise they would have been performed, as there have been men of genius and enterprise in all ages, and in all countries, and especially in all the parts of the Old Continent, which were formerly enlightened.

I will readily acknowledge, that I have made a bold assertion; but I will endeavour to prove that it has not been rash. Ask the Dutch and Chinese, especially the last, whether the thing is practicable or not? The United Provinces of the Netherlands are entirely founded upon the slimy sediment of the Rhine, and other rivers; and the whole empire of China is like a well cultivated garden, without any waste land of any sort, tho' much of it was at first marshy and slimy, and overflowed by the tides, which is a proof that the thing is practicable.

Most of the great works that have been performed in ancient times, were marks of vanity and ostentation, which were raised high above the surface of the ground for the gaze and admiration of the world. The list of great and useful works, planned and executed for the general good of society, is but small. Some little, it must be acknowledged, has been done in later ages, by a few commercial nations, for the convenience of mankind, and furtherance of navigation and commerce.

The rest of the world presents almost an universal blank, with respect to great and useful works for the lasting benefit of mankind, China always excepted. Great monuments of ostentation are to be met with in many parts of the world,

world, which have been celebrated and admired through a length of several ages.

As a further proof that the above assertion is not rash, but reasonable, I will suggest a few hints concerning the means and methods how such great and salutary advantages can be attained, as to double the means of subsistence, and to double the health and happiness of many and extensive regions of the earth; and, in pursuance of this design, I will begin with the rivers.

The fertile banks of great rivers have always been the delighted haunts of social industry; and it is generally in these situations that we meet with the arts and with commerce, plenty and wealth; but the greatest number of the largest rivers in the world are now under the dominion of the pestilence, &c.

Let us deliberate a little upon the means of driving these squalid enemies of the human race away from their ancient reign. If we are friends of mankind, we cannot be better employed. The Dutch and Chinese have shown us what banking and sluicing will do; and their method is so well known, that I will not lose time with it. But I do not approve of the practice of banking rivers, excepting only where the tide is concerned. We are obliged to raise banks to keep out the tide, which overflows such land near it, as only appears

pears from under water the greatest part of every day.

It generally happens, I may almost say that it universally happens, that the beds and banks of great rivers are already too high, especially in the low plains and valleys, and near their influx to the sea ; and, therefore, it would be preposterous to raise them higher by banking, notwithstanding the sanction of custom. Where new land is formed by great rivers in level plains, and near the shores of the ocean, the present banks, and sometimes even the beds of the rivers, are higher than part of the plains, and most of the morasses, upon both sides of them ; and, therefore, to bank them would be to enlarge the collateral lakes and morasses, which are situated without the banks, and to prevent the water of them from returning at all into the channel of the river again ; of consequence, our business is to sink the bed of the river ; and when the bed of the river is sunk sufficiently lower than it was before, we then facilitate the draining of the morasses and damp land upon both sides, make it fit for any manner of culture, and insure the crops from being destroyed or hurt by future inundations.

Before we point out the manner and method of deepening the beds of rivers, it is necessary for us to examine a little what sort of matter the beds
of

of them are composed of. In general, the beds of rivers may be divided into three different sorts or species, viz. 1. such as are sandy and slimy; 2. such as are gravelly; and 3. such as are rocky. Each of these divisions will require, in some particular respects, a different management in sinking the beds of the rivers. I will begin with,

I. The sandy and slimy beds.—Nothing has a greater tendency to hasten the choaking up and raising the slimy beds of great rivers than drift-wood. In the rainy seasons, which commonly is the time when the greatest quantity of snow is dissolved among the lofty mountains of the torrid zone, and other places, the land floods are then so very great, that the banks of the rivers are undermined, when great pieces of land rush down, trees and all, into the floods.

In these seasons, great numbers of the largest trees in the world will be driven forward by the prodigious force of mighty torrents, until they arrive at the plains, and there they will be lodged and entangled in all directions, both in the bed of the river by the way, and also near the bar or influx with the tide, in the countries of America; Africa, and other places; and the sand and slime gather about these entangled trees, and soon raise the bed of the river higher than the plain or new land; sometimes upon one, and frequently

both sides ; and when the river is thus raised higher than the collateral plains, it will of necessity deviate from its former course, and form new channels ; and these new channels will be choaked up in their turn, and others made one after another in the course of time ; and this undoubtedly is the origin and natural cause of great rivers entering the tide by many mouths.

Now, it appears to me, that there are only two great operations to be performed in order to deepen the bed of this sort of river. The first is, to collect and confine the several streams and mouths of the river into one channel ; and the second is, to take all the roots, trees, and other obstructions out of that channel ; and then the weight and force of the united and confined stream will carry away the sand and slime along with it into the ocean.

When these two arduous tasks are performed, the sandy and slimy river will deepen of its own accord. If once the trees and other obstructions are taken out of the channel, the weight and force of the united stream of a great river will scour away the slime with ease.

Let us now consider how these two great branches of work are to be performed : With respect to the first, that is the collecting of the scattered branches of the river, and confining them in one, it is very difficult to point out
with

with precision the method that should be followed in different places, as circumstances will vary considerably ; and therefore, we should also vary the method, in order to follow nature, which will always be found to answer best. However, we may suppose it will frequently happen, that the best way to collect the scattered streams at the mouths or influx of rivers, and confine them to one channel, will be, to drive in two rows of piles upon each side of the river, leaving a proper and sufficient space between them ; these rows or lines of piles to be strongly wattled or woven with long branches, or with under-wood, of a tough and durable quality, the small ends or grains of the wattling to come out next the river, and to go or lean with the stream of the water. The two rows of piles upon each side of the river must be wide or narrow ; that is, the space between the two rows or lines must be wide or narrow, in proportion to the magnitude and force of the river ; and the piles must also be proportioned to the weight and force of the stream which they are to confine.

The space between the two rows of piles upon each side of the river must be filled up with earth, &c. dug out of the new channel of the river, and raised at least as high as the piles and wattling ; and if turf can be had, especially marshy turf, I apprehend, that the in-
side

side of the row or range of piles next the water, opposite the old channels of the scattered streams, should be lined with a dyke or wall of turf well built, and beat strongly together, so as to keep out water.

When the space between the lines of piles upon each side of the river is filled up as high as the upper edge of the wattling, then let it be stuck full of strong aquatic plants. The piles should also be made of aquatic plants or trees, and the bark left on them, to the end that they may take root, and grow up along with the strip of planting within the rows of piles.

Without the tropicks, there are but few plants that exceed the willows, for taking root and growing hastily in water, and in all wet places; and most of the species of willows produce a congeries of roots, which are admirably adapted for resisting and turning water. There are generally abundance of mangrove trees in most of the rivers between the tropicks. A broad row of mangroves, or other large and strong aquatic plants, well grown upon each side of a river, will at once be a very beautiful, and a very effectual method of confining a river within the lines which are made for that purpose. Such aquatic trees as strike their roots deep, or that have a thick congeries of roots like the willow, should be the best for this purpose.

The

The magnitude of the river, even in the greatest inundations, must be considered in forming these lines. It is absolutely necessary to leave sufficient room for such a body of water to pass through, without rising so high as the upper edge or top of the piles and banking; and therefore, the distance between the lines for the channel of the river, must every where be in proportion to the magnitude of the river at its greatest swell.

But it is proper to remark, that too much room would be nearly as bad as too little. In too much room, the river, when low, would be apt to scatter within the lines; and of consequence, the stream would not be so deep and convenient for navigation. I imagine, that the best rule we can have for judging of the proper distance between the mural lines for the channel of the river, will be the real breadth of the river, where it is actually confined between its own natural banks.

In order to find out this real breadth, you must go up the river until you find it thus confined between banks upon both sides, even in the greatest floods. Examine how wide it is in such a place, and how deep in dry weather when the river is low; and from the knowledge of these circumstances, you will be enabled to judge what space or breadth you should leave between your lines for the collected stream of the river.

Where

Where circumstances will allow it, as great a length of the river as possible should be made to run in a straight line. An artificial curved line or course for the channel of a river would be a very bad one; because a heavy stream of water striking against a bank in any direction, would undermine and bring it down; whereas, it slides by smoothly when the river runs in a straight line, especially if the deepest part is in the middle. There are generally large extensive plains between the influx of great rivers and the mountains, or any considerable rising grounds; and the greatest part of these maritime plains, upon both sides of the rivers, is new land, formed by the rivers from the spoils of the mountains. A straight line should be drawn for the artificial channels of the rivers, through the whole length of these plains, between the rising grounds and the sea, or at least so far up as they begin to branch. When the course of a river is thus straightened through the plains, it will be a great advantage to navigation, and also a great safety to the lines, which are formed to confine the river in one channel.

When the scattered branches of the river are brought to run all in one channel, the united stream will wash the sand and slime off the drift-wood which is buried in it, and discover where and how it lies; and when it is discovered, it will

will be necessary to get it out, in order to deepen the channel of the river. We must now consider how this arduous task is to be performed.

For this purpose, it will be necessary to build a flat or square bottomed barge or float, the size of which, must be proportioned to the size of the trees, and the supposed difficulty of drawing them out. This floating vessel may be either made of a square, or of an oblong square form, though it should not be above eight or ten feet more in length than in breadth. It must be built very strong, and particularly, there must be a strong beam right across the middle of it below, in which beam a large socket of brass must be sunk, to receive the pivot or end of a large iron gudgeon. The sides and ends of the float should be raised from five to eight or ten feet high, in proportion to the size, and then it must be covered with a good stout deck. A winch, crab, or capstane, must be erected in the middle of this float; the beam or axle of which requires to be very stout, with a strong gudgeon in the lower end of it, which is to move in a socket in the strong beam at the bottom of the vessel. The upper end of the axle must come up through the deck, where you must build very strongly about it, and yet so as to allow it to turn about freely. This windlass or capstane must be turned about with four, five, or six large and strong capstane

stane bars or levers. The length of these bars must be regulated by the length of the vessel; so that when a man goes round at the extreme end of one of the bars, he goes close to the head and stern of the vessel; and if it is not built square, but longer than it is broad, then a stage or scaffolding must be erected upon both sides of it, in order to bring the upper deck to be as broad as it is long, and then the men can go quite round at the farther ends of the levers without shortening them. The barrel or axle of this winch must be fitted for winding a strong rope about it, both above and below the deck, if it is found necessary and convenient. When you go to work with this float, you must moor it at some distance upon one side of the middle of the channel, where you are going to draw the trees out of the bed of the river. If you have dry land near enough upon the far side of the float, it may be moored by driving poles into the ground and fastening ropes about them; but if the dry land is too far off, then you must moor it with a couple of anchors. If it is not moored strongly, the capstane will draw the float to the tree, instead of drawing the tree to the float. When the trees to be drawn out of the bed of the river are large, the capstane rope must be strong; and sometimes it will happen, that some part of a tree will stick fast in the mud or sand, which

which will greatly increase the resistance; and this circumstance requires the rope to be so much the stronger. Proper grapnels must be fixed at the end of the rope, sufficiently strong and well constructed to lay hold of the trees, and there should be grapnels and ropes of several sizes.

When there are large and heavy trees lying fast in the mud, it will require a large float, a strong winch, and a strong rope and grapnels, to move the trees from their beds in the mud; but when a large tree is once moved and drawn loose, the big rope and its apparatus, being unweildy, may be taken off, and a lesser one employed to draw the trees ashore. I suppose, that it will be necessary to have a port-hole in the side of the float, immediately below the deck, for the rope to pass through from the capstane-axle; and there must be a roller made to turn under the rope at the port-hole, to prevent the rope from chafing.

When some trees are drawn out, the stream of the river will discover more; and in order to procure a stream or current of water, to scour away the sand and slime off the trees, it will be proper to begin at the mouth of the river, because you are sure of having a current there when the tide is out. The vessel is either always afloat, or else once every tide at high water; and, therefore, it can be shifted a little up the river at pleasure. I suppose, that it will be proper to take

out the timber which appears upmost first, without endeavouring to get at what lies deeper down; and when you have gone over it all once, as far up as circumstances require, then come down, and begin again at the mouth or influx of the river, and go over it a second time, and as often again as may be judged requisite and necessary to sink the bed of the river to the full depth it is capable of. During the time of this operation, care must be taken in the wet seasons to keep the river from overflowing its new banks; and if it can be kept within the lines or artificial banks, the floods will do much more good than harm to the operation of deepening, as the weight and force of such a vast body of water will scour away the sand and slime, which will facilitate the cleaning of the channel from every obstruction.

When the bed of a river is cleared to the full depth which the tide will admit, it will then be proper to make collateral cuts through the lines or artificial banks upon both sides, in order to drain and improve the land, which is now so far laid dry, that it will not be overflowed by the river any more; and if any part of the land next the sea should be overflowed by the tide at some of the former mouths of the river, before all the branches were collected into one, it will be necessary to use proper means, by banking or otherwise, to keep out the tide in such places from
overflowing

overflowing large pieces of good land, about which I will not pretend to give any directions, because circumstances will vary less or more in every different place; and, therefore, no general directions will suit all places.

It is only some of the salt marshes next the sea that will require banking to keep out the tide: All the fens and swampy lands further up the river will, I suppose, be considerably higher than the surface of the river, at all times, when the bed of the river is sunk low enough; and, therefore, the improvement of those fens will be an easy task when the improvement of the bed of the river is completed. As few cuts as possible should be made through the new and artificial banks of the river, and any that are made should be well secured, to prevent the stream from washing away any part of the lower angle or corner of the canal.

If any trees should prove so large, and sunk so fast in the mud, that they cannot be drawn out with the winch, it may in that case be necessary to cut them in the water, and draw them out piece-meal. A species of saw may be contrived for that purpose, to cross-cut a tree under water.

This may frequently be found necessary where some of the trees are large and long, and entangled
in

in the mud by the roots, and many spreading branches.

II. I will now give some directions for deepening the gravelly beds of rivers.—The same river may have a bed of sand and drift-wood in one place, and a bed of coarse gravel in another. When the bed of the river is gravel, it must be deepened by dredging; but the common method of dredging in use for deepening harbours, and the like, seems to me to be too tedious for deepening the bed of a river, where the operation is to be performed upon a great length of surface; and, therefore, we must contrive a method of raking or drawing the gravel to one or both sides of the bed of the river. For this purpose, it will be necessary to have such a flat-bottomed float as before described; and indeed it is chiefly for this purpose that such a float becomes absolutely necessary.

In some situations, it may happen, that a vessel of a different and better construction may be necessary for weighing up the drift-wood out of the mud, instead of dragging it horizontally; and where weighing it up will answer best, the float in that case should be more in the form of a ship; and, therefore, I will suppose, that a ship should be in readiness, and should be employed where circumstances require it, as such a vessel will be much

much more managable in the water in all sorts of weather, and will be easier moved up and down, and across the river, than a clumsy square log of a float, which would always be slow and difficult to move in the water.

If at any time a tree should prove refractory to the force of the winch, such a properly built vessel might be fastened to the tree at low water, when the tide is quite out, which would be moved and lifted up at the return of the tide before high water; and when it is weighed up out of the mud or sand, such a vessel can be moved with the tree expeditiously to a proper place for depositing the drift-wood.

This ship, or properly built vessel, will be of further use in drawing a large spiked roller up and down the channel with a wind sail. Let this roller be made large and heavy, with strong iron spikes placed pretty thick in it. When this is drawn up and down the channel as it turns round, the iron spikes will tear up, and loosen both sand and gravel, and the weight of heavy currents will sweep it away.

But with respect to such places in rivers, where the bottom or bed is gravel or shingle, the flat bottomed square float is necessary, because such shingle and gravel must be dredged or drawn to one side of the river, and sometimes to both sides, when circumstances make it convenient.

The

The square float for this purpose must be large or small, or of a middle size, in proportion to the breadth of the river, and of the sort of gravel to be dredged. If the river is very broad, the float must be large, because the weight of the apparatus is considerably augmented when stretched out to a great distance ; and where many great stones are lodged among the gravel in the bed of the river, it will require the more strength to draw them out.

We should now consider what sort of apparatus will answer best for scouring and deepening the stony and gravelly beds of rivers. It will require some sort of grapnels to fasten upon, and draw out great stones. If the stones are very large and heavy, perhaps, that some instrument near the form of a ship's anchor, with a double or treble fluke, and more crooked than a common fluke, may answer the purpose.

What I mean by a double or treble fluke, is to have two or three flukes parallel to one another upon the same side of the shank, and so contrived, that they may all grapple, and keep a firm hold or gripe of the stone, until it is drawn ashore by the crab or capstane. In deepening great rivers, where there are many stones of various sizes, it may be necessary to have two or three sorts and sizes of these stone grapnels. Large stones, besides their own weight, will frequently be

be imbedded in sand or gravel ; and, therefore, every part of the apparatus must be powerful to draw them out of this bed. For scouring the gravelly beds of rivers, I would propose a sort of large rake, with strong iron teeth. For this purpose, get some strong curved pieces of oak, elm, or other strong timber, to make what may be called the heads of the rakes. The head of a stone rake, or a gravel rake, may be from four to six or eight feet long, as circumstances admit and require.

The shingle in the channels of some rivers is exceeding hard, occasioned by the weight and force of the stream, and of the admixture of small gravel, sand and slime, in which the large bowlders or bullets are fast imbedded. For deepening such channels as these, the head and teeth of the rake must be short and very strong. Where the gravel is more loose, disunited, and moveable, the head and the teeth of the rake or dredge may be considerably longer. These heads must be from eight to fourteen inches diameter, in proportion to what they have to do. The head should be strongest in the middle, and a very little tapering towards both ends, in order to admit of a number of strong iron hoops being driven very tight upon it, to keep it from bursting or splitting when at work. The shank of this instrument may be like the shank of an anchor,
with

with a ring or loop at the far end, to fasten the capstane rope to ; but there is no occasion for a stock, or that transverse piece of timber at the far end, which is necessary upon the shank of a ship's anchor, to conduct the fluke to stand perpendicular to the horizon. The length of the head of this instrument is sufficient to keep it right in the water. I observed before, that the head should be a little curved, and the iron shank must be inserted into the concave side of the head.

The end of the iron shank should be made thin and flat, that is, of a broad square, not above an inch, an inch and a half, or two inches thick, according to the size of the instrument, but it must be broad, in proportion to the thickness of the shank, so as the whole may be equally strong. The mortice in the head should be made to receive this flat iron tenon by driving it in tight, but without bursting. A washer or flat iron ring must be put upon the end of the tenon, which reaches through the head ; and above the ring, a strong locker or cottrel must be driven into a hole, made for the purpose, in the end of the flat iron tenon, to prevent it from drawing out when at work. The shank must have two flays to branch out from the middle of it, one upon each side ; and the extreme ends of both the flays must be fastened to both ends of the head, which will keep

keep it steady from yielding any way when at work.

The teeth and grappling-irons of this instrument must be long or short, strong or weak, in proportion to what they have to perform. Where the gravel is coarse and hard, and as it were cemented together with sand and slime, the teeth must be short and very strong; and where the gravel is looser, and without a great mixture of large bullets, the teeth may be proportionably longer, and more in number. They may be from eight up to eighteen inches long, or more, without the wood, in proportion to their strength, and the roundness and condition of the gravel they are to dredge. The teeth should be made in the strongest form possible, and a little curved, or bending forward towards the point.

The end of each tooth or iron spike, which goes into the wooden head or frame, must be square, and each of them must be drawn up tight and firm above, either with lockers or screw-nuts, with washers or rings under the nuts. The screw-nuts is the best method. The mortices which are to receive these iron teeth should be so pierced as to incline the teeth to lean forward a very little, like the teeth of a garden rake, which will make them stronger, and more apt to keep what they have before them. This is no more than

the description of a prodigious rake, with a very large and strong wooden head, hooped with iron, a strong iron shaft or shank, and iron teeth proportionably strong. It now remains to be considered, how this instrument is to be used most effectually and most expeditiously in deepening rivers; and I think this the most difficult point to be determined of any I have yet touched. When it is out at the extreme distance from the vessel, where it is to begin to work, there is no difficulty in bringing it home to the side of the vessel; as for this purpose, in ordinary cases, it only requires the strength of men to go round with the capstane bars, and one or two men below deck to coil the rope properly as it comes in; but the greatest difficulty is, how to take it out again expeditiously to the place required, in order to fetch another stroke, and so on. I have examined several methods for that purpose, but I will only point out the one which appears to be the most effectual and expeditious, which is to carry it out every time with a boat made for the purpose. This boat must be built short, broad, and strong, able to carry a quantity of ballast greatly above the weight of the instrument. A pulley or shave must be made fast to something upon the further side of the river, opposite to the place where the float is moored. If the river is narrow, it may be fixed to a pole or post, driven or sunk

sunk into the ground, or to an anchor ; but if the river is very broad, it may be necessary to fix it to a boat floating at anchor. A small rope, long enough to reach twice over the river, from the fixed block or pulley to the main float, must be drawn through the shave or pulley upon the far side of the river, and the one end of it made fast to the head of the carrying-boat, and the other end brought about the spindle or axle of the capstane above deck, but the contrary way from the big rope, which is to be managed below deck.

A pretty strong but short rope must be fixed about the middle of the head of the drag, or about the shank close to the head, and the other end of it to the stern of the carrying-boat. Perhaps, it may be necessary to have a small windlass upon the stern of the carrying-boat, to enable one or two men to lift up the drag or rake so far off the ground, that it will swim clear of the bottom.

When these several ropes are thus fixed, then the capstane must go round backward, or the contrary way from drawing home the drag, which at once draws the carrying-boat away from the float over the river, and lets off the big rope.

It will be understood, that the small rope which reaches twice over the river, has two or three turns round the capstane spindle, but the contrary way from the big rope ; so that, by this motion

motion of the capstane to let off the big rope, it draws out the carrying-boat over the river, without any assistance from the men in the carrying-boat. When the carrying-boat, with the instrument or rake hanging at the stern of it, is as far out from the float as shall be judged necessary, then the men in the boat must slacken the rope to let the drag fall to the ground, and then let the capstane go round the right way, which at once draws home the drag with the big rope, and the carrying boat with the small rope. In settling these matters, and fixing these ropes, it must be so contrived, that the big and little ropes are wound off and on equally fast, otherwise there may happen some jarring and hindrance in the operation, which, if properly adjusted, will go on regularly.

There must be a small anchor dropt a good way up the middle of the stream, with a line from it to the carrying-boat, which will enable the men in the boat to regulate it, so as to drop the drag where they please, either further up or down the stream. When matters are thus adjusted, there is little more to be done in ordinary cases than to work the capstane backward and forward, to lift the drag off the ground when it has brought home its quantum of gravel, let it down again in the proper place, and then to remove the big float and the opposite fixture with the pulley up or down the river, as occasion requires.

When

When the gravel is loose and fine, or small, the teeth of the drag must be thick set, or numerous, and near one another; and experience will shew if it should be necessary, in such a case, to have a board or box, or some sort of device, upon the head of the rake or drag, to receive, contain, and bring home a greater quantity of the loose gravel at each draught. There are men of genius and acuteness in all countries, who know how to make the best use of all occurrences, so as to improve a general plan.

So far as the tide flows, the float, &c. can be moved up and down at pleasure; but far up a country where the tide never flows, it may be difficult to make a proper use of the float, unless the river is very broad, as well as very deep; and therefore, in order to deepen a narrow river, and one of middling width, far up the country, either for improving the navigation of the river, or for draining land, or both, it will frequently be necessary to have a crab or winch erected upon land; and it will be very easy to have one upon land with equal, and even superior powers to that on board the float.

When a winch or crab is erected upon land, the several members of it should be fixed together with screw-bolts, so that it may be easily taken asunder and put together again; and where the ground is level, it should be capable of being

being moved up and down the river side upon round pieces of timber or loose rollers.

By these methods already pointed out, the gravelly and the slimy beds of rivers may be deepened at pleasure. When drift-wood and such rubbish is removed, the stream, when collected and united in force, will wash away the slime, and carry it forward into the tide; and when the boulders, bullets, and rounder gravel is drawn ashore, the smaller sand will be carried forward by the force of the stream; however, it may be necessary, sometimes to have drags, with teeth pretty close to one another, in order in some cases to draw very small gravel ashore, especially where there is not a strong current or stream; and it will frequently be necessary to remove the gravel drawn ashore by dredging, off the banks of the river, to prevent the surges, the tides, or the land floods from washing it into the channel again. Spiked rollers may be of use for small gravel as well as for sand and slime, where there is a good current of water.

III. The rocky beds and channels of great rivers are most difficult of all to be deepened, and in some particular places, it may be quite impracticable, when a large river runs a great way upon a pavement of very hard rock which

which is concealed under water. However, all the rocky beds of rivers are not so desperate.

It is common in all parts of the world for large rivers to be obstructed in their course, and raised too high, by a bar or narrow ridge of rock, running quite across, from the one side of the river to the other, which generally makes a waterfall over the bar. These obstructions sometimes form the rivers above the bars into great lakes; in other places, into large morasses, which are lakes nearly filled up by the sediment of the rivers; and in some places, the lakes and marshes are so well filled up, as to produce meadows and firm pasture land upon both sides of the rivers, which is the very best condition of the valleys and plains above the rocky bars; yet these meadows are overflowed by every inundation from the mountains, and they remain under water during the rainy seasons, which, in some countries, continue near one half of the year. In these, and like circumstances, it is proper to examine if it is practicable to cut down the rock, to give the river a lower and a freer passage. If the bar of rock can be cut down, and sunk from ten to thirty feet lower, as may be requisite, and the passage of the river made wide enough over the ridge of rock, I suppose that generally the point will be gained.

Let

Let us now consider how this difficult piece of work is to be performed. It is impossible to imagine all circumstances relating to places and things which a person has never seen, which makes it difficult even for a man of science, to point out the best possible method of executing such a piece of work. However, it generally, if not always happens, that in the dry season, when the river is low, some part of the rock will be out of water, upon one side or other of the river. Upon this dry rock, the workmen should begin as far down below the bar and water-fall as possible, and cut a deep and wide trench in the rock, parallel to the stream of the river, quite up through the bar, and as far above as may be judged necessary.

A banking of turf should be made between the cut and the river, to keep the water off the workmen, in case of the river swelling a little after a shower of rain, and the trench in the rock should be made deep and wide enough to contain all the water of the river in dry weather. When this parallel trench is carried far enough up the side of the river, all the water must be turned into it, and a wear or dam must be made in a diagonal direction across the river, below the head of the trench or new channel, to prevent any of the water from running in the old course over the ridge of rock, and then the labourers may begin
low

low enough, and work down the bar of rock to the depth proposed, leaving a thin partition of rock between themselves and the artificial trench, to keep off the water while they are at work.

If this work is well executed, and the bar of rock sunk low and wide enough, it must have the effect of draining the plains above, and of preventing their being overflowed in the rainy seasons, which will render them fit for any manner of culture; and it will produce the additional happy effect of a more pure and salubrious air all over those plains.

When such bars of rock are improving, care should be taken to work down the principal channel lowest in the middle or near one side, so as to improve the navigation of the river over the rock.

The greatest difficulty in the way of repairing the rocky beds of rivers for improving river navigation, is how to get the better of sunken rocks, which are always under water, and yet are so shallow, that vessels cannot pass without striking upon them, which is very dangerous.

I have considered all the best methods of working down rocks under water; but as a full description of the methods, and of the several instruments, would be tedious, and as it is very difficult to work away rocks under water to a sufficient depth for the purpose of navigation, I

think it much better to advise attempting either to turn the river off the sunken rock while they are working it down, or to make a new channel for the river fit for navigation in such places, in order to shun these sunk rocks.

Where the inland navigation of a large river is very bad, with rocks or other obstructions for a considerable length, and that the improvement of the old, or the making of a new channel is impracticable, then they should make a sufficient navigable canal with locks, to pass by such a difficult part of a river; the canal to communicate with the river below and above the difficult part.

There is a simple and frugal method of deepening and improving small and middling rivers, for the purposes of preventing the inundations of the flats,—of preventing them from changing their course,—from endangering towns or fields,—or for any other purpose. Any alterations, uses, or changes, may be made of the most of rivers, by very simple methods, and the most simple are generally the best.

The course of all the rivers of the world depends upon the figure and declivity of the surface of the earth, in the countries through which they run from their sources to the sea. A level plain, or a flat valley of very little declivity, is liable to be sanded and otherwise injured by the inundations of the river which runs through it, whether that

that river is great or small. Gravel, sand, and all the rubbish which the currents bring down from the mountains, is sure to be lodged in great quantities in such plains and valleys; and this rubbish fills up the natural channels of the rivers in such level situations; but when the natural channels, or beds of the rivers, are filled up and obstructed, they will overflow their banks, and cut new ground after every heavy shower of rain. In this case, several parts of the old channel will be choaked up; but when the flood has run a little way in the newly cut channel, it will return again into the old one further down; and this is the origin of the very irregular and winding course of some rivers. When the bed of a river is thus raised, and its channel obstructed, whether near the tide, or further up the country, it is sure to overflow its banks in every land flood, and each of these inundations is sure to lodge more matter in the plain or valley, which gradually increases the irregularity and disorder in the course of the river; and thus a great deal of mischief is done every year, by the greatest number of all the rivers in the world,

Fire and water are necessary, excellent, and powerful servants, when properly employed, and directed by the wisdom and industry of man; but they are always dreadful, and frequently very destructive masters. The wise and industrious
Chinese

Chinese have made the best use of all the water of their empire, and their whole empire is a well watered garden.

All other countries of the torrid and temperate zones of the earth might likewise improve their rivers, and they might make immense improvements of their lands, and of their commerce, by means of the rivers, if they had but a part of the wisdom and industry of the Chinese. But almost all the other princes of the world think it more glorious to lead out their people to be destroyed in the sanguine field of battle, than to lead them out to plow, and to other improvements of their country, like the Chinese emperors.

Above I have pointed out some of the methods of improving the channels of great rivers. I will add one observation to what I have said above before I proceed to the small rivers, viz. where the bed of a large river is greatly filled up, so as to be raised on a level with, or above the collateral plains and marshes, and that the channel of it is greatly obstructed by the roots, trunks, and branches of drift-wood carried down by the floods, and lodged perhaps to a great depth in many parts of the true channel of the river, which may be the cause of its dividing into several branches before it reaches the sea, and its entering the tide by many mouths; in this case, it may be proper to examine the level ground and the

the morasses upon both sides of a large river, to see if a new channel can be cut and made for it upon one side or the other of its present course, in a straight line, from the tide all the way up to the place where it begins to break off, and to separate into several branches, and, in this place, to bring the whole collected stream of the river to run in the new channel. Where this may be done with propriety, care must be taken to make the new channel deep enough near the junction with the old. When the river is turned into the new artificial channel, care must be taken to defend the old passage of the water with strong bulwarks, in which a great many piles made of whole trees must be driven, to prevent any part of the river from ever passing that way again; and these trees should be aquatics. However, in general, where too much drift-wood, or some such obstruction, does not make it impracticable, the method pointed out above of removing obstructions, and confining the river between lines or parallel bulwarks, in a straight course through the plains from the high grounds to the sea, will, I apprehend, be the most eligible plan of operation; and afterwards to deepen this artificial channel between the lines by degrees. But I will here beg leave to enter a caveat against this or any other method of banking without deepening, excepting against the tide only, because it will be labour

labour lost where the tide is not concerned. The beds of all or most of the great rivers of the world, are raised too high with the matter lodged by their own streams, most of them above the level of the collateral plains and morasses, which is the general cause of their dividing into several branches before they reach the sea; and, therefore, any attempts to confine such rivers in channels which are elevated above the collateral plain countries, would prove ineffectual and useless, however great the expence and labour might be.

We should have three great objects in view when we undertake the deepening of great rivers, viz.
 1. The acquisition and improvement of a great extent of rich land upon the rivers near the sea;
 2. The improvement of navigation, which always increases the value of the land; and 3. The acquisition of a pure and salubrious atmosphere, where putrid unwholesome vapours formerly arose from the stagnant morasses, and poisoned the air; and this third blessing enhances the value of the other two improvements; and without it, the most flourishing state of society and commerce can give no true and lasting felicity. But neither of these great and valuable acquisitions can be obtained by an elevated channel of the river.—The collateral plains and morassy grounds cannot be drained into a river, whose bed is on a level with, or perhaps higher than some parts of those morasses;

morasses; and, of course, the putrid stagnated morasses, and the pestilential air, must remain as they were, nor can the navigation be good in such a river, because it is liable to many obstructions, and to change its dry weather channel.

A regular deep channel cannot be preserved without sinking the bed of the rivers.

It is said, that the American river Oronoko overflows its banks near six months in the year, during which time, some fertile islands, and immense tracks of the richest soil in the world, upon the banks of this great river, lies steeping and souring under water. But when the incessant rains and melted snow which feed these inundations begin to fail, and the river falls within its banks, the vapour which the sun exhales from the raw and humid surface, from whence the water has newly retreated, corrupts the air, and makes one of the richest countries in the world a scene of misery, sickness, and death. What a blessing would it be to the miserable inhabitants of the banks of that river, and the many other great rivers of the world which overflow their banks, and enter the sea by many mouths, if they were improved, and led to the sea in one united stream, and their channels deepened, so as to prevent the inundations, to facilitate the draining and meliorating their fertile banks, and the adjacent plains and morasses, and to improve the in-
land

land navigation, and purify the air! These are invaluable blessings, which a sufficiently deep and wide channel, and a straight unobstructed course of the rivers, would facilitate the acquisition of. It is a confined, shallow, obstructed course, that is the first cause of stagnation. A deep and regular channel will pour out more water into the sea in one hour, than a shallow, irregular, and obstructed channel will in six. We have a familiar demonstration of the truth of this frequently before our eyes. How many small rivers and large rivulets have we seen, which made a lake of a valley after every great shower of rain, while they were allowed to creep and warble through their old irregular, obstructed, meandering channels, which run clear off in the greatest floods, when new channels were cut for them in a straight line up the valley, and some of them will not half fill their new and regular channels.

This is a perfect demonstration of the truth of my doctrine respecting the improvement of the channels of great rivers which are subject to inundations. We have only to make the channels regular, deep, and wide, in proportion to the magnitude of the river, when in flood; and the water will run off in a ratio, or true proportion, of the different quantities of water in the great and little rivers,—of the depth and wideness of their

their several channels, and of the velocity of the current of each; and a straight and uniformly regular channel always facilitates and increases the velocity of the current. If the several mouths of the Danube, and many other European rivers, were collected into one stream, and their channels made sufficiently deep, wide, and regular, for facilitating inland navigation, what immense advantage would it be to the commerce and agriculture of the countries thro' which they run to the sea.

The inland navigation of many European rivers might be greatly improved at small expence, by deepening their channels, as directed above; which would be an immense and a lasting benefit to the manufactures, commerce, and agriculture of the countries upon both sides of such rivers.

With respect to the small rivers of Britain, and other places which are subject to inundations, or to deviate from their proper course, and injure towns, roads, fields, or single buildings, the most simple and frugal method of deepening and improving the channels of such of them as run upon a bed of stones, is, to get a number of men, women, and children, in summer, when the river is low, and pick up all the stones out of the proper bed or channel of the river, from the bigness of the fist and upwards, to the largest of all, and lay them down upon one or both sides, as the

situation and figure of the ground admit ; always taking care to lay them so far out of the current, as to give room enough for the river in flood, and to be out of danger of the floods sweeping them in again. When all the stones which are presently seen are carried out, let the work stand until more are discovered. The first heavy shower of rain will wash away the sand and gravel, and discover more stones, which may be also carried out as soon as the river is low enough, and a second flood will still discover more deeper down ; and if all the great and small stones which are laid bare by every flood, are carried out of the proper channel, a river, by this simple method, may be deepened as low down as you please, without any material expence. This method of deepening or sinking the beds of stony rivers is as effectual as it is simple ; and I am confident, that it will not cost five per cent. of the expence of any other method that can be devised. That it is effectual, I know by experience ; and a few people will clear a great extent of channel in a day, unless many of the stones are so large as to require levers, and much labour to remove them. When the river is too big for men to stand and work in the stream in summer, then the channel must be cleared with stone and gravel rakes, as directed above. A very little work well timed, upon this principle and method, will frequently prevent

prevent the mischief and havock which many rivers make by overflowing and changing their course. By lifting the stones chiefly out of the side, or course where you want the river to run, you may by degrees humour the current, and lead it any way you please.

Where the beds of rivers are chiefly sand or gravel, their channels must be deepened and improved, by dredging with rakes of different sizes, as directed above, and by rolling with spiked rollers, which will lift up the sand, and mix it with the water, and the stream will carry it away by degrees.

I am fully sensible, that all the methods of deepening and improving the channels of great rivers, which I have pointed out, are arduous, expensive, and difficult. The work, in many instances, is of such vast magnitude, that it may appear to many quite impracticable; however, genius, industry, and a true spirit for improvement, seldom look upon difficulties in this light, and especially when stimulated by the necessity of the improvement, and the glory and advantages to be gained by it. What has man failed to accomplish, when the end and the means were equal to the undertaking? When the great Creator bestows genius and a comprehensive mind upon any of the children of men, he also with it communicates the image of his own omnipotence,
which

which qualifies the man of genius to plan and execute great works, both for utility, and for splendour and ostentation. Look abroad into the world, and consider a little what great things have been done; and are our powers more confined and weakened now, by the very great improvements in philosophy and science? No. Philosophy now applies the principles of mechanics to the useful arts, and valuable discoveries and improvements are daily made, and making, which are of inconceivable benefit to society.

If the nations and rulers of the world would combine their forces, and make good use of the means which Providence hath put in their power, nothing would be too hard for them. Would they but employ, for one age, the one half of the men and money which is destroyed by them, in every age, upon useless, cruel, and capricious wars, the great works which I point out might be considerably advanced in that age; and what is the object? The means to be employed in any undertaking is always to be justified by the object or end to be gained thereby; and here the object and end is truly laudable and great; no less than the acquisition of another world to be added to the present, without enlarging the bounds of the terraqueous globe, and that world, so united, many times more salubrious, fertile, and convenient for the mutual commerce, wealth
and

and happiness of society than the present, in all parts of the earth! The uniting the several quarters and families of each continent together into one compact convenient neighbourhood, by improving the navigation of the rivers and the waste lands, and by correcting and improving the climates of the world, and driving out sickness, and weakening the power of immature death.

A war upon want, sickness, and death, is worthy of a new set of knights errant; and in these papers I point out a large field for adventure, and all their exploits are sure to be recorded in the rolls of Heaven.

What exploits can be more worthy of a place in the celestial chronicles, than procuring plenty, health and convenience to millions of the children of men! Your Alexanders and Cæsars are famous in the records of men, for having destroyed millions of the human race; but what good has either of them done? But the wars I point out are against the worst enemies of the human race, sickness, famine, and premature death; and the conquerors in this field would be immortalized, as the fathers and lasting benefactors of mankind to endless ages; and they are certain of securing endless praise from God and all good Spirits, for having done good in this world; and as a secondary motive to such worth and greatness, there is so much gratitude among
men,

men, that the memory of such illustrious actions, such unbounded benevolence, would be handed down to latest posterity.

These great works of deepening rivers and draining marshes, for increasing and improving the soil, and correcting climates, would be convenient in many parts of Europe, and peculiarly necessary in Asia, Africa, and America.

If the Danube and other great rivers of Europe were properly deepened, and otherwise improved, it would greatly improve inland navigation, as well as the soil and climate ; and then we should not hear so frequently of towns and villages, and people, and stock, being swept away, and of such other losses and devastation from almost every land flood that happens ; and, moreover, such deepening would greatly increase the wealth and prosperity of Europe ; and by the salubrity and equanimity of climate which the improvements hinted at would procure, disease and famine would not be experienced as now. The malignant and sickly climates of some parts of Asia, and of almost all Africa, and the extreme cold in winter, and malignant climates of America, are almost entirely occasioned by the watery, humid, and undrained state of that country. The greatest part of the surface of the continent of America is covered with lakes and woods, the stagnations of rivers overflowing their banks, and of consequent morasses.

rasses. Upon such a face of the country, the rays of the sun are plunged and absorbed in a watery surface, or in the damp shades of the woods, and the atmosphere is always overloaded with humid and putrid vapours. To say with Raynal and others, that the woody, humid, and cold state of America are marks of infancy, or of its having lately emerged from the waters of a deluge, is nonsense. Without the effectual application of the improving hand of man, these marks of imperfection will continue and increase to eternity. The great rivers of America have formed prodigious tracks of new land upon the shores, and in the plains; the beds and channels of these rivers are every where choaked up and risen, and continually rising much higher, by which extensive lakes and morasses are formed, and still increasing; and without the improving hand of man, they will still increase, and grow worse and worse, while the world endures. The woods of America now cover immense tracks of the best and naturally driest lands, which continually increase in humidity, by the stagnations of decayed vegetables; and this evil will never decrease by the ordinary course of nature; and it is well known, that all the rays of the sun are absorbed in the damp and putrid umbrage of immense woods, from whence a tainted sickly vapour must exhale for ever, as well as from the

stagnant

stagnant and putrid morasses, both of which emit living steams, loaded with various *animalculæ*, which are sickness and death to the human race, and to most of the useful domestic animals ; and, therefore, unless the rivers of America are deepened, the morasses drained, and the prodigious forests cut down, or greatly thinned and perflated, the climates will for ever continue as they are, or grow worse.

It is well directed industry that meliorates the various soils and climates of the nations, and makes them fertile, pleasant and salubrious. There is an infallible proof of the truth of what I assert, in America itself, to be adduced from experience, without recurring to the principles of philosophy, and in the experience of all other countries over which the hand of industry has passed. The climate is already very much altered for the better in the provinces of North America, where a very small part only of the woods have been cut down, and of the lands improved ; but very much remains to be done there yet, towards the effectual improvement of the navigation of the rivers, the fertility of the soil, and the salubrity of the climate and atmosphere. Deepening the great rivers of America, as low as the tides will allow, in the maritime plains, and as low as circumstances will require in the inland countries, would at once improve the navigation of those rivers, facilitate

litate the draining of the morasses, and prevent in future the inundation of the plains in rainy seasons. Collateral cuts from the deepened rivers, properly directed through the lowest parts of the morasses, and these intersected by sufficiently large ditches, will effectually drain the stagnations in the plains upon both sides of the rivers. The main drains or collateral cuts from the deepened rivers, may be laid out and made in such a manner as to answer for navigable canals, which may come to be of inconceivable utility in other extensive countries, as they now are in China.

Where the morasses are deep and boggy, allowance must be made in the depth of the principal canals and intersecting ditches for the subsiding of the chaotic surface, when the humidity is drained out of it. But this is too particular for my plan, which is only to touch at some of the principal parts of my subject in brief and cursory hints.

Deepening the beds of the great rivers of America, and ditching the morasses, will drain an immense quantity of water off the surface of that continent. When the beds of the rivers are so deepened as to prevent inundations in rainy seasons, such plains upon the banks of the rivers, as now only afford indifferent pasture in the dry months of the year, may then be improved for proper crops. Proper canals and intersecting

ditches should also be made in the savannahs of America, to carry off the water as it falls upon them in the rainy seasons. Stagnating waters sour the surface of the ground, and taint the air with putrid exhalations; and, therefore, the sooner the rain water runs off these extensive grassy plains, the sweeter the grass and the purer the atmosphere will prove.

The proper management of the woods of America would also have a mighty effect towards improving the climates and atmosphere of that great and now unhealthy continent. If the surface of America was improved like the surface of China or England, the climate or atmosphere would become as temperate and salubrious. The condition of the surface of the ground, and the state of agriculture in a country, makes and determines the climate and quality of the atmosphere more than its situation in point of latitude. This is a fact remarkably well experienced in all well cultivated countries, and in the near neighbourhood of all dry mountains and sandy or gravelly plains. To purify the atmosphere from the damp and putrid exhalations of the prodigious forests of America, wide avenues should be cut through them in the direction of the prevailing winds, and great care should be taken to drain them from all humid stagnations. There are certain points of the

the compass from which the winds blow the greatest part of the year in all countries.— The avenues through the woods should be cut in the line of these prevailing winds, that they may blow through freely, to perflate every part of the woods, and disperse and carry away the generating damps and putrefactions of the forests. The columns or strips of wood to be left should be as narrow and as thin as possible.

The real demands of the country for timber should be the only rule by which to regulate the breadth of the strips, and the distance of the trees from one another in each strip; and the hedge row trees should be taken into the account of the quantity of timber necessary. The land of the avenues between the strips should be well drained and improved, and every part of the strips should be perfectly well drained, because one acre of humid ground or under wood will produce more putrid vapour to taint the air, than a thousand of well cultivated land. Particular care should be taken to be very exact in draining and perflating the woody parts of the countries between the tropics, which undoubtedly will have a mighty effect in purifying the air, and improving the climate of those unhealthy regions. In warm countries between the tropics, no humid stagnations should be left upon any part of the surface of the ground, as such places are the fertile wombs

wombs and nurseries of sickness, and immature death to the miserable inhabitants. The utmost care, skill, and exactness should be employed in draining every foot of ground in these warm climates, and in perfuming the woods, by cutting avenues through them. A much less quantity of wood should be left in warm countries, than in those that are cold, because there is much less needed, especially for fuel. If the lands were properly improved in these warm countries, the prunings of a small quantity of wood would go far towards the necessary supply of fuel; but as the sun is frequently hot in these countries, the shade of strips of wood may be very necessary for man and beast; however, if they are necessary, they should be very narrow, and, perhaps, they should be formed in undulating lines, that the cattle may find shade in the concavities of the undulations, when the sun is in a line with the strip, which will happen every day.

It was observed before, that as little humidity as possible should be left upon the surface of the ground in warm countries. In draining the savannahs, the arable and pasture lands, and the strips of wood in such countries, as many covered drains as possible should be made, especially in level ground, because stagnant ditch water in such places teems with myriads of reptiles, insects, and *animalculæ*. The Kings of Spain and Portugal, with

with their subjects, are highly interested in the purport of these observations. Were the rivers deepened, the morasses and shallow stagnant waters drained, the woods perflated, and mostly taken away, and the lands well drained and perfectly cultivated, the climate and atmosphere of South America, and the Brasils, would become as healthy, pure, and salubrious as some parts of the continent of Europe. If the woods of *terra firma* were cut down, and the lands perfectly drained and improved, and no stagnations of any kind left to putrefy, Carthagena, Portobello, and other like places, would then become the scenes of firm health, beauty, joy, and vigorous activity, as well as of fertility and abundance of all things. This is the effectual method to drive away squalid sickness, misery, and want out of the world, even from every climate. In pursuing such improvements, special regard should be first paid to maritime places, which are conveniently situated for extensive commerce, because such places are remarkably useful and necessary to further the improvement of the rest of the world.

The purport of these observations is of such magnitude and importance to the welfare of the world, and especially of the new world, that they merit a serious enquiry whether they are founded in truth or not, and they will bear the strictest scrutiny. They are founded upon solid principles, and they
have

have the experience of ages, and of all cultivated nations, on their side. The truth of them can be proved to the clearest demonstration, and innumerable examples could be produced in proof and illustration; but such a design is entirely out of my plan, which is to drop as many general useful hints as possible in a very few pages, and leave them to be examined and improved by the world; and I trust that they will stand the test. Look over the face of the continent of America in its present state: what does the sun shine upon there? Upon woods, lakes, and marshes—upon the wide inundations of great rivers, or upon the slime which they have deposited—upon large plains and savannahs, which are choaked with the putrefying fruits of their own fertility; and what can the sun exhale from such a surface? Nothing but the fetid steams of stagnant water, and of putrid vegetables; and these lose none of their malignant qualities by floating in the air, but carry sickness and death upon the wings of the winds, or rather in every motion of the lungs of the wretched inhabitants of those countries.

While the richest fragrance of flowers and fruits exhaled from the enamelled meadows, fruit trees, and well cultivated fields of the most of Europe, a considerable part of Asia, and a small proportion of Africa, perfumes the atmosphere with pleasure, health and joy; every gale in America,
and

and most of Africa, is at the best overloaded with humidity, and generally tainted with the squalid steams of stagnant water and putrefied vegetables; and magnifying glasses shew us, that such water, and such rotten and rotting vegetables, are replete with various forms of life, so minute as easily to rise and float in the air, imperceptible to the naked eye of man; but this living atmosphere is sickness, pain, and death to the human race, and to many other animals.

O ye rulers of the world, ye men of wisdom and power! weigh these considerations, which are seriously and honestly, though rudely, laid before you, for your information and emolument! The beds of the rivers may be deepened and improved,—the morasses and shallow lakes may be drained,—the unnecessary and noxious forests may be cleared away off the face of the earth. The four savannahs may be ditched and sweetened, and the idly fertile plain fields and meadows which emit deadly vapours, from the putrid redundancy of their now useless productions, may be perfectly drained and well cultivated. And what would be the consequence of all these great works, supposing them to be performed? It would (as I said before) add another world to the present, without enlarging the bounds of the earth, and that world would be capable of maintaining nearly as many men and beasts as the present;

present; and, therefore, it would double the stock of both, with the means of employing and maintaining them. It would connect the various parts and families of each continent together, into one great and populous neighbourhood, and procure them health and plenty, with all the conveniencies and all the advantages of mutual intercourse. By removing the stagnant, crude, and putrid causes of the corruption of the air, it would be the effectual means of procuring and diffusing a more simple, pure, and salubrious atmosphere over all parts of the globe; so that all men every where may draw in health, joy, and long life with every breath, and perhaps they might by degrees, in the course of time, recover the strength and longevity of the Patriarchal ages. And are there any other such objects of pursuit and acquisition in this world? None that I can comprehend. What are all the mines of gold and jewels in the world to these acquisitions? The means and accommodations of life, and of multiplied population and industry, and of mutual and extended commerce, is the real wealth and happiness of the world; and all this of course results from the proposed improvements.

I wish to say as little as possible upon every part of my subject, to make myself properly understood; but perhaps I have said too little about the woods of America; and when I speak of
America,

America, I beg leave to observe, that the same improvements will be useful and salutary to Europe, Asia, and Africa, under nearly the same parallels of latitude ; and with respect to the rivers and morasses in all latitudes whatever. I advise clearing away the most of the wood of America off the face of the country. But I am aware that the inhabitants will plead the necessity of preserving the woods for the important purposes of building and fuel ; and I am sensible that they cannot subsist without both, and therefore, a sufficient quantity of timber must, some how or other, be reserved or procured for them.

In order, at once, to remove the noxious effects of the present woods, and to give a supply equal to their necessities, I propose, that the sides and summits of dry mountains should be covered with wood, and that the dry banks, or sides of ravines and dales, be filled with wood ; and, I imagine, that these situations, along with the hedge rows, where they are used, and some few very narrow strips, would be sufficient for all their necessities.

The sides of dry mountains, and the dry sides of dales and ravines, will certainly grow enough of timber for the tropical inhabitants, and for those of all other warm countries ; and therefore, they should let no wood grow upon their plains, nor upon any of their humid or very fat grounds,

excepting some single trees, and a few rows or lines to afford a shade from the burning rays of the sun : And, if all the woods were cleared off the plains and richer soils, and all the morasses and savannahs drained, and the face of the country well cultivated, the cold parts of America would then become much warmer, and of a more equal temperature in all seasons of the year ; and the climates and districts which are at present noxious, sickly, barren, and mortal, would become perfectly healthy, fertile, and agreeable.

The sum of all the advantages which the nations of the world will reap by the great works and improvements proposed to them, may be briefly comprehended in three general heads, or propositions, viz.

1st, The acquisition and improvement of numerous parcels or tracts of land in almost all parts of the world, supposed to be nearly equal in value to all the land in the world at present under culture, considering the fertility and convenient situation of the lands to be gained for industry and commerce.

2^d, The removing of all the stagnant waters, putrefactions, and other causes of noxious vapours, off the face of the earth, and creating a simple, pure, and salubrious atmosphere over all parts of the globe, which would procure more temperance and equanimity of climate and weather.

ther every where, without too much rain, &c. in those places which are now deluged and steeped in water for half the year, or more; and, in course of time, the health and longevity of the human race would be greatly increased.

3d, The improvement of the inland navigation of the world would greatly enhance the value of the first article, and would be a very great convenience to all parts of the earth. And here I may venture to make a plain and obvious remark, viz. that these three acquisitions are so far connected, and depend so much upon one another, that each of them enhances the value of the other two, and neither of them would be of half its real value without the others.

Before I conclude these cursory hints upon this great subject, I beg leave to express my regret that I cannot with equal confidence point out a certain and infallible method of improving the sandy deserts of Barca, Arabia, &c. which are a vast nuisance upon the face of the earth; and, therefore, I could wish to say something to the purpose upon such an interesting subject. But I find it exceeding difficult to treat this topick in a practicable and satisfactory manner.

It is unnecessary to give any history of these deserts. It is well known, that the sandy plains which are found in so many parts of the world, are pernicious in three different ways :

1st;

1st, As they occupy such extensive tracts of the surface of the earth, which is now entirely useless, but which would be exceedingly valuable in such situations, if only middling soil.

2^d, These sands are always dry and parched. There is not sufficient humidity in such places to absorb and qualify the burning rays of the sun, and therefore, in the hot weather of dry seasons, the natural heat of the sun in such places is so much increased, that the atmosphere becomes too hot for the life and health of man or beast; and this excessive heat rarifies the air to such a degree, as frequently to generate such high winds and tempestuous weather, as sweeps all before it.

3^d, These winds and tempests make the sandy plains so exceeding troublesome and dangerous for travellers, that many thousands of lives are lost in them. It is not uncommon for a whole caravan, consisting frequently of more than a thousand men, besides a still greater number of cattle, to be buried at once under the sand, which, in a strong wind, overwhelms them in a moment; and it has sometimes happened, that whole armies have been buried alive under tremendous billows, or moving mountains of sand. I need not say more to make it appear a desirable acquisition for the welfare of the world, if such a dreadful nuisance could be removed out of it, or at least be so far remedied, as to prevent its effects.

fect from being so very pernicious and destructive.

Let us now enquire if the thing is at all practicable; and here I can assert nothing with confidence. All I pretend to do, is, with diffidence, to suggest such thoughts as occur to me, which appear to have some probability of success. High mountains of sand, or such deserts as are of very unequal superficies, are quite out of the question. It is only sandy plains that we suppose any way practicable; and with respect to these, it is supposed, that most of the sandy plains in the world are situated lower upon the plane of the horizon than the sources of the nearest rivers to each of them; and if so, it is further supposed, that some parts or branches of such rivers can be turned out of their ordinary course or channel, and led or conducted on to the sandy plains. Where the sandy plain is extensive, a small river will not be sufficient, and, therefore, it is necessary to look out for a large one, which, perhaps, is not to be found at a moderate distance. However, supposing it should be more than a hundred miles off from any part of the desert, it is, notwithstanding, necessary to have it.

The expence of cutting a new channel for such a river, to lead it to the nearest part of the sandy plain, will be very great; and we suppose, that the benefits and conveniencies to be gained by it,
will

will also be very great. However, when the river is brought to the sands, the work is only begun. It is necessary to spread it over the sands in a lake of some feet in depth, and to keep it there for a considerable period of time, if not for ever, which will every where be an arduous task, and in some places quite impracticable.

This lake is to be made by banking quite round the sandy plain. This bank, mound, or rampart must be of great length to encompass large sandy plains ; however, it will not in all places require to be of great height ; and as turf and clay are the most proper materials, these will generally be found at a small depth under the outskirts of the sands, and they are easily dug and put together ; and in some places the skirts of hills and rising grounds will answer as part of the surrounding artificial mound. It is supposed, that three or four feet deep of water, all over the sandy plain, is sufficient ; for although hillocks of sand should rise far above the surface of the water, the wind will soon blow them down into it, which, in the course of no long time, will produce a level, or a vast, though shallow lake.

I am aware, that the evaporation would be so very great from such an immense surface of water, that few rivers in the dry seasons would be sufficient to supply the waste ; but the rivers of those countries generally overflow their banks
once

once a-year at least; and care must be taken to make the new channel sufficiently capacious to bring enough of water to the sands in the wet seasons; and the inundations of the rivers will bring down from the mountain such a quantity of earth and slime, as will in the course of time form a coat of soil over part of the sands, upon which vegetation will soon appear, even under water; and, when the water decreases in the dry seasons, it will increase or thicken to a good surface or coat of grass.

Where the line of circumference round the outside of the sands is not upon a perfect level, they should only aim at laying a certain district or division of the sands under water at once, supposing it was no more, or even less, than a third part at one time; and it should be considered, whether or not more than one river can be turned on to such irregular, or on to any extensive deserts. When great rivers are turned out of their ordinary course for the purpose of flooding sandy deserts, I am sensible, that the navigation from the sea, if there is any, will be rather injured than improved; however, if the new channel is formed with a view to that purpose, the inland navigation may be greatly improved, as, by reason of cataracts and water-falls, many rivers are incapable of inland navigation in their present state. Where the figure of the surface of the ground makes

makes it necessary to flood the sands piece-meal, it is presumed, that the district of sand which is under water will, in a few years, be levelled by the winds, and the agitation of the water; and that the surface of the sand will be so immixed with the mud or sediment of the river, as to produce a regular coat of grass; and this improvement will be effected the sooner where the rivers are always muddied by the inundations from the mountains, and this always happens where the mountains are composed of argillaceous strata. When the surface of such portions of sand are covered with a sufficient coat of grass, instead of being a nuisance as formerly, they will then become of great use and value for pasture. Extensive sandy deserts are generally situated between the tropics, or in warm climates, without them; and these sands greatly increase the heat of such climates; but where water can be spread over such sands, it is well known, that heat and moisture encourage and increase vegetation; and, therefore, a few years would make a wonderful change on such sands. However, where they are covered with a coat of grass, they must not be too soon, nor too rashly deprived of all moisture, lest the heat of the climate in dry seasons should parch the surface, and endanger its being broken up again by the winds. The sandy plains between the tropics will soon experience a surprising change

change of climate when laid under water. Instead of the burning heats which are now so intolerable and destructive, a plentiful and salubrious vapour will then be exhaled from an extensive surface of water and humid sand, which will cool the air, and make those countries healthy, fertile, and pleasant, which are now unsufferable, even to the raging blood of the lion and tiger, who are obliged to plunge into the rivers up to the nostrils, or to retreat into the deep recesses of gloomy caverns, during the heat of the day.

Deepening the rivers, draining the morasses, extirpating superfluous forests, and flooding the sands, with other proper and necessary improvements of the ground in the continent of Africa, would totally change the constitution of the climate and atmosphere of that quarter of the globe. Such salutary improvements would be productive of wonderful revolutions in that great continent. It is generally known and allowed, that Africa is most conveniently situated for extensive commerce ; and that there is, in many of the known regions of that continent, a deep and excellent soil, tho' in most places either covered with wood, or steeping in morasses, or fermenting in the putrefying fruits of its own fertility, all of which produce such an immensity of noxious reptiles, insects, and *animalculæ*, that the air and the waters are filled with them ; and, of course, health,

plenty, and happiness are banished, and will never visit those regions, while indolence and barbarism bear so much sway as at present.

Industry and good government, with an unity of design, among the ruling powers of that country, for the general good, would soon make it a paradise; but the foundation of such happiness must be laid by Europeans. Were Africa properly improved, many extensive regions of it might vie with any part of the known world for the excellence and abundance of its productions, and for extensive and prosperous commerce, and every human felicity.

The great importance of this subject is a sufficient apology for my proposing it.

If the nations and rulers of the world will not regard what such an obscure person says upon such momentous topics, that is not my fault. I have done my duty.

But why should I suspect, that the best intentions, and most honest endeavours, should be altogether lost? Some good philosopher may take notice of these rustic hints, assume the subject, and communicate it to the world in more ample form, and a better dress; and then others will be emulous to follow him, until at last it becomes as popular a subject as it is a fertile one; and there never was a subject of greater magnitude
and

and importance, for the improvement and welfare of the world, proposed by man.

There is no less proposed than such real and solid improvements of all parts of the world as are actually accomplished in China, and in some other places; and it is supposed, that these improvements would enable the earth to maintain near double the number of its present inhabitants, and that they would be much better maintained than multitudes are in the present unimproved state of many countries; that by these improvements, the several communities on the same continent would be much better connected together, in mutual intercourse, by the improvement of inland navigation; and that all nations would reciprocally reap the benefits of these improvements, by the multiplied means and conveniencies of enlarged commerce. And, to crown all, the extirpation of the superfluous woods, deepening the rivers, and draining the morasses of the world, would bring about such a total change of the climate and atmosphere of all nations, that sickness and pain would in a great measure be banished from the children of men, when they would every where breathe a purer air, and enjoy a more wholesome diet, the consequences of which would be the enjoyment of firm health, longevity, and happiness in all parts of the earth.

F I N I S.

ERRATA.

VOL. II.

- Page 8. line 19. *for* grilly, *read* gritty.
- P. 58. l. 24. *for* from east to west, *r.* from west to east.
- P. 91. l. 15. *for* grounds, *r.* ground.
- P. 95. l. 3. *for* system, *r.* systems.
- P. 95. l. 17. *for* new earth, *r.* a new earth.
- P. 112. l. 10. *r.* must subside mixt and blended.
- P. 125. l. 20. *for* about five, *r.* of about five.
- P. 130. l. 21. *for* origin, *r.* organization.
- P. 131. l. 19. *for* and upon, *r.* within and upon.
- P. 135. l. 11. *for* real and partial, rest at a height, *r.* real or partial.
- P. 141. l. 17. *for* range, *r.* ranges.
- P. 147. l. 8. *for* on an accurate, *r.* that on an accurate.
- P. 204. l. 1. *for* deposition, *r.* disposition.
- P. 289. l. 26. *for* the hunting of leopards, *r.* hunting leopards.
- P. 332. l. 13. *for* being thrown out, *r.* thrown out.
- P. 335. l. 9. *for* small-pox as, *r.* small-pox is.
- P. 387. l. 19. *for* I have, *r.* I had.
- P. 396. l. 13. *for* or variety, *r.* or vacuity.
- P. 420. l. 7. *for* Ameer, *r.* Amur.
- P. 469. l. 22. *for* these, *r.* that.
- P. 469. l. 25. *for* impracticable, *r.* practicable.

